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Journal of the Society of Arts.

FRIDAY, MAY 11, 1855.

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EXTRA-ORDINARY MEETING.

Monday, May 7, 1855.

An Extra-Ordinary Meeting was held on Monday evening, the 7th instant, for the purpose of resuming the discussion upon Colonel Cotton's paper, "On Public Works for India." Edwin Chadwick, Esq., C.B., presided, in the absence of Robert Lowe, Esq., M.P., who took the chair on the last occasion, but was unable in this instance to do so, owing to his parliamentary duties.

The Secretary stated that he had just received a telegraphic message from Mr. John Bourne, of Greenock, to the effect that a letter he had written on the subject before the meeting had been omitted to be posted; but that he concurred in Colonel Cotton's views as to Indian river navigation. [This letter has since come to hand, and will be found printed *in extenso* at page 449.]

The Chairman then called upon Mr. W. Bridges Adams to open the discussion, when that gentleman read an abstract of the following paper :—

CANALS AND RAILWAYS IN INDIA.

By W. Bridges Adams.

In every subject under discussion the first object should be to settle the terms of the discussion. The terms of the present discussion have not been settled, and thence probably has arisen much of the variance of opinion. India is a term meaning almost every variety of soil, climate, and circumstances, from the snows of the Himalaya to the hot swamps of the Hooghly. We might as well dispute of the whole continent of America, and determine that everything good for the Gulf of Mexico is also good for Cape Horn. To assert, as Colonel Cotton would appear to do, that no railways should be made till all canal power were exhausted, would simply be to say that mankind in India should only dwell along the navigable streams, or streams to be made navigable, or capable of being worked by very ordinary appliances. To assert, on the other hand, that no water conveyance shall be used, because railways are a convenient means of transport, would be an absurdity. To assert, also, that no railway ought to be made where water transit exists in a similar direction, would be to determine on a great waste of very valuable time amongst the most intellectual members of the community—a process fatal to the general progress of the masses. In all times and ages rapid transit—rapid as compared with the general movement of the community—has been found a necessity of government and progress. The ancient Peruvians, lacking the means of mechanical and animal locomotion, established a communication of human runners, at posts a few miles apart, in order to convey messages rapidly. Modern Indians are used as beasts of burden to convey their ruling classes at the rapid rate of four miles an hour, because they find it a necessity to travel faster than bullock waggons, through districts where water transit exists not, and horses cannot be maintained. It might be said that people ought not to travel at a cost of cruelty, but they do, and they will in failure of non-cruel methods; and amongst the national cruelties that have been abolished by the advent of railways, that of the cruelty to post-horses is not one of the least; a cruelty, be it remembered, not of the poor, but of the rich; a cruelty not of the race-course or of the hunting-field, but of the road; a cruelty in which the legislator, returning from his duties to his estate in the country, indulged in as prominently as other men, when giving an extra half-crown to the post-boy to induce him to give an extra spurring to the bleeding ribs of the jaded post-horse.

Fast travelling must be, to induce civilization, even at the cost of stinted rations to the poor, who have to do the work at the outset. Not destructive fast travelling for whims, but travelling as fast as can be accomplished without greatly enhanced cost.

It is no argument against the construction of canals in India, as proposed by Colonel Cotton, that railroads in Europe and America have been constructed along the same tracks as canals and rivers. The construction of a railway does not prove that a canal is useless; on the contrary, it may happen that the canal and railway mutually help each other. A large transit of goods implies a large transit of passengers, and *vice versa*; and while canals are well adapted for heavy goods, they are too slow for light goods. There may happen circumstances in which the canal is practicable, and the railroad is not, as in swamps, but on the other hand the railroad is practicable in a vast number of cases where the canal is not, as in districts of little water and on very undulating ground.

A mechanical difference in the construction of the canal and the railway is this, the former must be a series of direct levels, with sudden drops, in the form of locks, whereas the latter may be a gradual incline. It is obvious that the incline does not increase the cost in making the line, whatever may be the case in working it. But locks and their maintenance do very seriously increase the cost, both of making and working.

Navigable canals are made because rivers will not run straight or level. Brindley, in his evidence before the legislature, said roundly, that "Providence made rivers to feed canals;" but the great Earl of Bridgwater, looking further, said the only fear he had for his canal revenues, was the possible contingency of "those ——— execrable —railways."

Canals belong to peculiar localities, such as Holland, where the water is in abundance, and it is almost needful to dig ditches to make dry land. In such districts a canal does not become a mischievous monopoly; but in England, which is by no means a dry climate, the canals were a monopoly, for there was only a given quantity of water, and it was all owned, and could not be increased by manufacture. That also might come to pass in India.

The railway came and beat down the monopoly. Iron is not limited, like water, and wherever a railway proprietary charge large fares upon an extravagant capital or a spendthrift working expenditure, there, infallibly, in due time, will parallel lines of rail be laid down. The only way in which a practical railway monopoly could be accomplished in England, would be to purchase two strips of land, east and west and north and south, in the form of a cross, and charge black mail to every one passing over it, as the barons did in the olden time, when there were no Acts of Parliament to make individual advantage give way to the public good.

Rivers and canals for navigation have been chiefly successful in temperate and cold climates, notwithstanding the difficulties of frost. The Hudson, which drains a large extent of lake district, is a case in point. It is only in such climates that the constant supply of water can be kept up. The Erie canal is the artificial drainage from the Erie lake to the Hudson, and this is carried over the valley of the Mohawk in a long wooden trough, upon tressels of great height, with a kind of wooden mantle-shelf on one side for a towing-path, the water pouring out at every joint in miniature Niagaras, showing that it is a raw material in great abundance. In hot climates, canals are chiefly made for purposes of irrigation; and where, in such climates large navigable rivers serve the purposes of transport, it is only because population has not sufficiently thickened to use up all the water for irrigation, or because the rivers run in such deep channels as to prevent it, forming, as it were, large sluices. The River Plate is one of those draining a large district, but so little used for irrigation, that the wide steppes of the Pampas, which could be made to absorb it all, are, in the absence ot a rainy year, a dry desert, in which the cattle die by thousands around the last muddy water-holes.

We have long been accustomed to read of voyages on the Nile; yet now there is a railway alongside it, and there is useful land enough to use up probably the whole of the water, were there means to lift it up; yet this river Nile, like the Indus, is not, and probably never has been, navigable to the sea. The Mahmoudieh canal, leading into Alexandria, is the artificial substitute for the impracticable channels of the Delta.

The Mississippi, like other great rivers, makes and unmakes islands, closes its channels capriciously, and opens new rivers along its course. It is ever bringing down detritus and making deposits where it lists, incessantly raising its channel and heaping up obstacles which oblige it to run over its banks, unless helped by human labour, which has now enabled ships to float above the roofs of the houses in New Orleans. The Ganges makes sport of the islands at its mouth in the same manner.

Whenever we find a river constantly keeping up a delta or a bar, we may take it for granted that the supply of water varies. The Thames has no delta, but it is carefully banked in and dredged when needful. In the rivers of hot countries, the rainy season brings down a torrent which heaps up materials serving to pond up the water when the rain ceases; and these bars are the impediments to navigation in the dry season. Removing the bars, the navigation would be open, but only till the water had all run out, which would be very rapidly. These bars, in fact, constitute a series of natural locks, between which the water lies at a level. These natural ocks Colonel Cotton would convert into artificial locks to be effective for navigation, but it would be necessary to run the stream into an artificial channel, to be out of the way of floods which would destroy the work of art. The canal is a pond without a current, and one of the troubles of ponds is, that they are apt to fill up with sediments. Moreover, these channels, if narrow, will only admit of towing, which needs a towing path and animal power. If propelled by steam the banks wash away, as is found in the Clyde, which is practically a navigable canal below Glasgow; and does not subserve the public want of speed as does the railway. And it is only in fine weather that the lowest possible fares will induce people to travel by water on the smooth Thames to Gravesend, and even then they return by rail at night to town.

Canals must make sinuous courses to keep the levels, much more so than railways, and thus increased distance is added to slow transit. And time is money, even to the labouring man, who has to eat every day, even though he were to travel for nothing. What workman goes to Birmingham from London by canal? It is a mere jest to allude to it.

Rivers, to be constant, must be dependent on some process of nature for storing up water. In Chilé and Peru the Andes perform the office by storing up the snow; but the rivers are little more than a hundred miles in length. In the Upper Ganges, the Himalaya range performs the same office. Mont Blanc and other mountain regions supply the Rhone, which was formerly a navigable river all the year round, while the snows were sheltered beneath the pine forests, and melted gradually. The pine forests being cut down, the Rhone is now an alternate mountain torrent and a non-navigable stream during great part of the year. The proof of this is, that within a few years past Lyons has been subject to periodical inundations which have washed down dwellings and stores constructed of unburned bricks. It is obvious that such buildings would not have been erected if they had originally been in risk of melting down like barley-sugar. The large American lakes which are drained by the St. Lawrence, and to which the limestone range of Niagara forms a bar, are fed by the rains and melting snows, and it is stated that their depth is decreasing by the constant felling of timber to supply the numerous steamboats, which exposes the snow to melt, and the water to evaporate. In Ireland the great bogs form a kind of natural springs, from which the water gradually oozes to supply the rivers. Other rivers are supplied by mountain caverns with large inlets and small outlets. In countries of continuous rain the rivers may be continuous without any of these resources.

In hot countries jungles may supply shelter for the water-courses, to prevent evaporation, but such must ever be a pestilential country, like the west coast of Africa.

Leaving the problematical question of navigable canals, we come to the question of irrigable canals. Of *their* value and permanent utility, if India is to make progress, there can be no doubt. Colonel Cotton cannot well over-rate them in this particular. My own belief is that in proportion as irrigation extends, population will thicken, and that ultimately it will be found that the whole of the water can be advantageously absorbed to render the dry land fruitful. In hot countries the roots of the plants appear to be the best absorbents. Rain is not favourable to ripening vegetation. But the process of irrigating land by open channels is a costly one. Along the channels there is a thick and tangled growth of weeds, requiring a constant expenditure of labour to keep down. In the beautiful plain of Valencia, in Spain, the whole water of the river falls short of the necessities of the cultivators, and leaves much good land useless, and generates a perrénial strife amongst the peasantry, which rises into an occasional tumult, with loss of life, and has to be put down by the soldiery. There is a proverb about the water:—

"Una mitad al cielo,
Otra mitad al suelo."

"One half to heaven,
The other half to earth."

Próbably of all the water that springs from the mountain, one-third is absorbed by the sun, and another third by the porous channel, to grow weeds, while only one-third reaches the cultivated land.

In hot Spanish countries, with irrigation, it is customary to plant the acequias or irrigation channels with trees, to prevent evaporation. But there is yet wanting a cheap and efficient mode of conducting irrigation water under ground, and when that takes place it will be the most valuable gift that modern science can bestow on India, saving human labour, and preventing the waste of water. The water must be filtered before it enters the channels, to prevent deposit, and the channels must be easily accessible, to clear out obstacles. If Colonel Cotton will set himself to work to solve this problem, he will be a still greater benefactor to India than he has yet been.

One chief objection that Colonel Cotton makes to railways is, that by their cost and outlay they will prevent the canalisation of the Indian rivers, which would be much cheaper per mile. Yet he says, that navigable canals are insufficient, and proposes as an adjunct light railways, the cost of which he does not tell us, though he asserts that the ordinary lines will cost £10,000 per mile. Now, a railway consists essentially of permanent way and rolling stock. These are the two items which cannot be done without, any more than the bridges and levelling. All else, expensive stations, &c., is a question of choice. The permanent way and rolling stock will not exceed £3400, per mile, and earthworks and bridges, at £1600 more, would only make up £5000 per mile. Horse railways, wholly of iron, to work into this as branches, could be constructed at between £500 and

£600 per mile, and by a horse railway, I mean a very permanent horse railway, and not a toy—horse railways that can be laid down by unskilled Indian labourers, after being shown how the first pair of rails go together. I go still further. There are districts where even railways to track light waggons by hand would be desirable, as in Welsh slate quarries, and they also should be constructed wholly of iron, for reasons obvious enough to those who have had to grub up thorny roots to boil their kettle.

I have for many years past been an advocate, in print and out of print, of light railways for steam power, of horse railways, and of portable railways. In the *Times* of January, 1850, and in the *Spectator* of February, 1850, these plans will be found favourably reviewed.[*]

The question of railways might be nearly an exact science, but it is far from that yet. Railways divide into two branches, tram ways, or trammel ways, in which the guiding power is on the rail, and railways proper, in which the guide is on the wheel. A commoner division is that of steam locomotion and animal locomotion, the structure varying with the loads to be borne. The railway is better than the trammel way, for several reasons, as it keeps clearer from dirt and obstacles, and engenders less friction. The mechanical principles which should govern the construction are the same in all cases.

As the object of a railway is to lessen the obstructions to the movement of rolling wheels, we may consider the rail and wheel as man and wife, not to be treated apart, for as a bad wife may make a miserable husband, so a bad wheel may spoil a rail, or *vice versa.*

The first thing to desire in a railway is that it should be as nearly as possible a horizontal plain, straight, and parallel between the rails.

Secondly. The rails should be virtually inflexible under the rolling loads. In making a girder bridge over a stream it is necessary that the depth of the girder should bear such a proportion to the length and load that it will not deflect in the opening. A rail is, or should be, a girder, likewise non-deflecting, and if the support below it be a yielding material, or solid discontinuous supports, the rail must be deep enough not to bend between the supports, or upon the unfirm material, or the result will be a line constantly out of repair, needing what is called maintenance of way and increasing resistance to traction. The pressure ought to be equally distributed, by the absence of flexure, and this can only be done by depth.

Thirdly. The rails should be laterally inflexible, or great friction will ensue by the rocking of the engine and carriages. They should be laterally straight, or a continuous sinuous movement will take place.

Fourthly. The junctions of the rails should be so arranged that while allowing for expansion and contraction the strength of resistance, both vertically and laterally, should be as great at all the joints as at the intermediate portions.

Fifthly. An efficient connection should exist between the two opposite rails, to keep them parallel.

Sixthly. The surface of the rails beneath the wheels should be so hard and tough that they will neither crush nor laminate beneath the rolling loads.

Seventhly. The bearing surface of the rails or supports on the ballast, should be of such area that the rolling loads will not disturb it.

Eighthly. The height of the wheel surface above the bearing surface on the ballast, should be the minimum, while the bearing surface is the maximum.

Ninthly. The rail should bed into the ground, to keep it steady laterally, and prevent rocking.

Tenthly. The depth of the rail below the bearing surface of the ground should be so much in excess of the rise above the ground, as to constitute a suspensive principle, in opposition to the principle of a prop, which is the common mode of structure. Where only light loads are required, the prop plan may be used for convenience, but it is not the form of greatest permanence.

Eleventhly. In maintaining the line of way, care must be taken to provide good drainage for wet weather, and easy means of watering in dry weather.

The construction of any railway, great or small, and its mechanical fitness may be tested by these rules. Various modes of construction may be used, but all should be firm without loose jolting, and though timber sleepers have their advantages, no doubt greater permanence may be attained by an iron structure. Cast iron, if in sufficient masses, will do, but wrought iron is the best, and to absorb mischievous vibration, loose timber blocks, analogous to wood-paving, and not structural, may be applied as a portion of the ballast at a cheap rate.

In laying the rails of permanent way, the upper or wearing surfaces are placed at an angle with the horizon of about one in twenty, in order to keep them parallel with the coned peripheries of the wheels.

Railway wheels are a peculiar structure, found only on railways and for common roads in the very rudest countries. They are not wheels in the proper sense of the word, the two wheels being keyed fast on a shaft analogous to a garden roller. The result is, that if they be of equal diameter, they have a constant tendency to move in a straight line; if of different diameters, they have a constant tendency to move in a curved line. To compensate for this evil, the peripheries are made in a coned form, of smallest diameter outside. This is said to compensate for curves, by the tendency of the centrifugal force to throw the outer wheels on their largest diameters, and the inner wheels on their smallest diameters, corresponding to the varying lengths of rail, *i.e.*, the wheels are supposed to move sideways. If they do this, they, of course, take the carriage with them. But the curves on a railway are not mere large curves, but an incessant series of small curves, varying with the position of the rail, the tread of the wheel being sometimes on the inner and sometimes on the outer side of the rail, and the glint which may be seen on the surfaces of the rails, is a sure indication that rubbing and burnishing, as well as rolling, is taking place; in short, even upon a straight line, if the cone of the wheel accurately fits the pitch of the rail, a constant grind must take place by the varying diameter. The wheels are really friction wheels, till by rubbing they diminish their bearing to something like a knife edge. How far this conical bearing is an advantage to the engine driving-wheels in giving adhesion, and how far it is an evil, can only be proved by trial against cylindrical wheels and level rails. The probability is that it is an evil.

That it would be an advantage to have cylindrical wheels for mere bearing-wheels there can be little doubt, for the purpose of running on a straight line; but the cylindrical wheels would be a disadvantage on a curved line, unless one were of smaller diameter than another, corresponding to the curve.

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[*] "A pamphlet just published, entitled, the 'Iron Ways,' will be read with satisfaction by proprietors of railway shares, for its hopeful anticipations of what may be effected towards a restoration of profits by the adoption of light and frequent trains. It also contains a number of suggestions on the general development of traffic, which, in point of ingenuity and completeness, as well as in the faith they exhibit in the extent to which the public would avail themselves of increased facilities, resemble the original Post-office plans of Mr. Rowland Hill."—From the *Times*, Jan. 25th, 1850, Money Article.

"REDEMPTION OF THE RAILWAY SYSTEM. — The author shows how the railway world can be rescued from its difficulties, and how the extension of a more manageable railway system, by its minuter ramifications into the very farms, would reconcile farming with free trade, as it would make transit easy both for produce and locomotive farming apparatus, and would thus bring a full manufacturing power and activity into the heart of agriculture. But although the view is put forth by a practical man, its reasoning is so clear, and its method of attaining the proposed end is so direct, that railway folks will pronounce it unpractical.' "—From the *Spectator*, Feb. 9th, 1850.

But permitting each wheel to revolve independently of the other, will solve this difficulty. Not with a fixed axle, as that would involve risk in case of heating. But with the axle revolving in the carriage boxes, and the two wheels revolving on the axle, there will be not merely a complete removal of curve friction, but a far greater degree of safety, inasmuch as if the axle heats, the wheels will revolve, and if a wheel heats the axle will continue to revolve. In ordinary practice the wheels will not revolve, as the friction of the axle will be less, but each wheel will revolve just so much as will compensate for the curves and irregularities, and the torsion of the axles will cease.

To illustrate these movements there is on the table a box representing a waggon frame and four sets of model wheels. One set are keyed fast on the axles, and are of equal diameter, one of them being shown as a disc wheel. These wheels, if placed beneath the waggon body, will move forward in a straight line.

A second set have the wheels keyed fast on the axle, with larger diameters on one side than the other, in the proportion of 18 to 15. These wheels, placed under the waggon-body, will, by reason of their varying diameters, roll on one side, while they sledge on the other, creating great friction.

A third set are of equal diameters, and all revolve loosely on their axles. These will run with the minimum of friction, either on straight lines or curves, and without regard to varying irregularities of the rails.

A third set are of equal diameters, and all revolve loosely on their axles. If they be placed under the waggon-body they will run nearly as freely as if of equal diameters.

But if the first set of wheels, of equal diameters, and fast on the shafts, be placed under a waggon body, so that the axles are not parallel to each other, the resistance will be very largely increased. In this case, also, the loose wheels will materially diminish friction and facilitate movement.

If, again, the two wheels on a side be not in the same plane, as when a blow sets the framing out of square, that also will generate friction, and retard the carriage. In this case, also, the loose wheels greatly facilitate movement.

In all cases the boss or centre of lever wheels should be as long as half the diameter, to prevent wear.

It has been alleged that loose wheels involve risk of getting off the line, by their free movement at points and elsewhere. This is only saying, in other words, that the more perfect the construction of the sledge, the less chance there is of the carriage moving freely. If curves be too sharp they should be provided with guard rails. But the simplest answer is, that loose wheels have run, and still continue to run, in France, where "they manage these matters better," both under engines and carriages.

With loose wheels accuracy of diameter is not required, and with fast wheels, however accurate they may be made at first—though they commonly are not accurate—they rapidly become inaccurate in wear.

Apart from the mechanical fitness of loose wheels there is an important commercial question. Of all forms of matter relative to packing and transport, railway wheels fixed fast on the axles is the very worst. It measures more with less bulk than any other known form, save empty packing-cases. With the wheels loose from the axles they may be packed in a small space, and they will be less liable to damage.

Between the wheels and the load should be placed efficient springs in all cases; but this is not a present question.

It is a common remark by persons of not very logical minds, that a thing is very well in theory but will not do in practice. If this mean anything, it is that the theory is a false one. A man putting forth a false theory may do so either honestly or ignorantly, and in neither case ought he to be implicitly trusted; but precisely the same remark applies to those who refuse to admit a true theory, or who suffer a true theory to fall dead for want of application. To the clear perceptive mind the true theory is as true and certain as the demonstration by practice.

To illustrate the theory of rails which I have set forth the large model on the table represents a rail of girder form, deep and wide, to give vertical and horizontal strength. The top of the rail is elevated less than three inches above the bearing on the ballast, while the width is 13 inches, or a proportion of about 26 to 5 in favour of steadiness. The total depth of the rail is 7 inches, and of this 4½ inches serve as a keel, to give additional steadiness by holding laterally in the ballast. The tie bars keep the gauge. The packing is very accessible, and the rail is really reversible. The rails and side brackets break joint mutually, and the manufacture is easily producible, and any part can be replaced without much waste. There are but four parts or types, and the commonest labourers can lay them down without error, while the whole is of wrought iron, and there is no timber to rot, and no mechanical work to do on the ground.

There are three other models—one of a bracket joint for a double head rail, increasing the mechanical efficiency and decreasing the cost. A second model of a similar joint for a mid-ribbed rail, to give lateral stiffness and resistance. The third is a girder rail and joint to be applied to cross sleepers or to detached blocks. This rail is very stiff, both vertically and laterally. All these are applicable to locomotive lines.

The bridge rail and joint with the tie bar are applied for laying down on the surface of the ground, or for cross sleepers. The rail is rolled with two lower ribs forming angles, over which the sides are drawn close by the bolts, clipping both rails and tie bar as firmly as a vice. The rail is thus deepened vertically, and rendered stiffer. The gauge is shown as 2 feet 6 inches. The rail is adapted to lay down without sleepers on the surface of the ground, and may be easily widened by longer tie bars. There is no timber or sleeper needed, and the rails may be moved at a moment's notice. The firmness of the joints makes the rails practically continuous bars. This rail is perfectly well adapted for horse traction, burying the joints in the ground, and leaving the rails to bear on the surface, or placing detached blocks of wood below them. The waggon wheels are to be cast sheaves, from 15 to 18 inches in diameter, and a single spring connecting the ends of the axles together on each side. The waggons will carry a load of 30 cwt.; or a lighter rail, on the same principle, may be used to carry 15 cwt. This same rail and joint increased one-half in size, and placed on cross timbers, would make the strongest, firmest, and cheapest of ordinary lines of way. Used without sleepers it would be found the simplest application for army and fortification lines, perfectly manageable by ordinary soldiery, and also for mineral and for agricultural lines, where horses are used.

This bridge rail joint has now been in successful use upwards of six months on one line, and is about to be laid down on four others. The bracket-joints are laying down on four lines.

Models are shown of these brackets full size, as applicable both to joint and intermediate sleepers. Mechanically this arrangement makes the rails much firmer, as they are lowered two inches on the sleeper; the undersides are not damaged by resting on chairs, so that they are really reversible; there are no pegs to get loose, and the weight of metal is considerably reduced as compared with the chair system.

An apology may be due for the prolixity of this detail, but upon the specific question of wheels and rails depends the result of profit or loss in railway transit.

And this brings me to a very important consideration of the question at issue. Colonel Cotton compares canals as they are, with railways as they are. But there is a manifest distinction. Canals, during the lapse of time from their advent to the present day, appear to have exhausted the fertility of the human mind as to their perfectibility. The only further move is to convert the external haulage of the boats to an internal propulsion. But this needs a size of canal not yet contemplated. But railroads proper have, as yet, only existed 25 years, and are far from having yet attained their possible perfection. I am not going, after the fashion of Brother Jonathan, "to draw a bill on futurity and cash it at sight," but I appeal to any competent and unprejudiced observer who is familiar with the items on railways of "maintenance of way and rolling stock," whether reasons have not been pointed out why there is hope for a very material diminution in cost and working expenses. With this proximate and more perfect result, then, must Colonel Cotton compare the water transit he advocates. We are a "practical" people, so practical that we have changed the very meaning of the word theorem, and made it to signify a fallacy, so that a man must forego the gift of speech and demonstrate in materials like deaf and dumb people, ere he can gain credence. He must not set up for a critic till he is prepared with something better than the thing he criticises. For this reason only have I loaded the table with models, which seem almost an insult to common sense, as embodying the merest truisms.

There is yet another question. The canal only follows the course of all the earliest settlements, the streams, and leaves untouched the hidden wealth of the yet desert. The railway opens up mineral and other wealth. It will, if rightly used, form a line of new streets and villages. It will bring squatters from all parts to its borders, just as the opening of the Erie canal gathered together what are called "forwarding merchants" from all parts of the Union. Yet another thing. The line of the river is very commonly unhealthy by its locality. The line of the rail will, probably, be much more healthy. The very rushing of the trains sets the stagnant air in motion.

In discussing whether a canal or railway is best, the discussion must, therefore, not wander all over India, like a desultory tribe of broken men, but must be confined logically and specifically to each given river in succession. Let us know the conditions of the river as to its amount of water at all seasons, the gradients of its bed—the obstacles in its course—soil and climate, and we can deal with the question as a calculation, whether it is desirable to make a railway or not in preference to, or in conjunction with, the rivers. All generalising, save as to theory, or laying down principles, is useless, when the question is one of fact, and of specific fact. It is as vague as the celebrated proposition, "Given the height of the monument, what is the depth of the Baltic sea?" or, to put it into an American axiom, "It is about as big as a piece of chalk."

Cotton is the staple subject. Let us know in how many localities, and of what extent, cotton grows; and, what is also very much to the purpose, in how many and what sized localities it may be made to grow along the course of the railways *in esse* and *in posse*. Whatever be the amount, there is no doubt that railways can carry it, if not on one line of rails, on two or more. With good gradients, a well-constructed engine, and waggons not damaging to the road, may transport from 100 to 150 tons nett at a rate of 15 to 20 miles per hour; and 24 trains a day might follow each other in succession without casualties; in round numbers, a million and a quarter tons per annum. But in such case only one uniform rate of speed could be permitted.

But the real cost of transit on Indian railways cannot be ascertained till a mechanically perfect system shall be adopted, and the fuel procured and manufactured on the spot, and water used in the boilers distilled by the sun, and returned in the form of rain to the Company's tanks, unimpregnated with earthy matters that destroy the boilers and impede the production of steam. Nor can the railway be properly maintained till provision shall be made for watering the road in dry weather as well as draining it during rain.

I must conclude by quoting the opinion of a very competent authority—Colonel Kennedy—on this question of canals and railways, in his work published in Calcutta, arriving at similar conclusions.

> "Whilst deploring that the characteristic energy of Englishmen, which has produced such marvellous results at home, should as yet have made so little progress in the physical improvement of India, there is still one small consolation. If India has been deprived of the benefits which energy has conferred upon England, she may now profit by the experience of England, and may save a vast amount of that progressive investment of wealth, which the results we now enjoy in England have cost. There, no fewer than four successive investments have occurred to effect nearly the same object, each, in its turn, superseding and rendering almost useless that which preceded it. We have had—
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> "First. The defective roads of intercourse of our forefathers, crossing hill and dale, and accessible only to back-loads, or lightly-laden carriages.
>
> "Secondly. The more civilized and profitable carriage roads of the present generation, which set the former aside.
>
> "Thirdly. The network of canals for carriage of merchandise.
>
> "Fourthly and Lastly. The railways of the present day, capable of doing the work of all, and with much greater profit and economy, if the errors at their introduction had been avoided.
>
> "The position of India at this moment, therefore, enables her to save the three first progressive classes of investment, and to effect at once the 4th and perfect class.
>
> "The national character of England, as well as the interests of about 150 millions of people, calls for an exertion both of judgment and energy in reference to this subject. It requires that the grievous impediments should be removed which affect Indian travellers of all classes, and which limit their progress to three miles an hour, in traversing the level and burning plains of this country, even in the neighbourhood of the great capital of India, and in the nineteenth century.
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> "The sound application of our English experience should enable us to avoid the waste that has been above referred to. It should warn us against constructing canals or the transport of merchandise, where the lines are fitted for railways. It should induce us, in opening ordinary roads in lines that are eligible for railways, to lay out all levels, curves, and fences on a principle that will admit of their future conversion to the more perfect purpose of railways without loss or waste.
>
> "A chief head of expenditure in the construction of ordinary roads, in the plains of India, consists in the metalling. A similar class of expenditure is required for railways, called, in the phraseology of the craft, ballasting. Thus we see that without, in any way, impairing the object in view, when constructing an ordinary road, it may be suited for conversion at any time to a railway.
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> "In selecting the position, we have only to ascertain that we have got the right general mercantile line, which should be equally our object if we looked to nothing beyond an ordinary road. In 'laying out and forming,' we have to regard the curves and levels with great accuracy, which produces neither difficulty nor cost, in a level country like that now under consideration. We should place the fences at a sufficient distance to admit, in future, of a double line of rails; and we have to lay down our metalling along one side of the enclosed line, which will afford, for the present, a perfect horse-carriage road, and will provide a ballasted bed, all ready for laying down a *single* railway track, at any moment that we can muster the required courage and energy to scare away the phantom which is now scaring us from adopting, at once, the complete and perfect measure required.
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> "In the observations I have made as regards canals, I should be sorry to be misunderstood, as I believe a certain class of canals, for the purposes of irrigation alone, is quite as essential a desideratum, as is the question of railways in India.
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> "The canal principle for irrigation should be looked to as affording the power to increase our produce, and should be carried to the utmost extent that the economising of water can require, so that our rivers may be made to distribute their waters, and exert their fertilising powers upon the earth, before flowing to the sea. If this principle were adopted, we should not find the devastating and mischievous effects at present produced in the low inundated districts, by what are considered ungovernable rivers. But commencing as near to their sources as requisite, the waters would be, at proper intervals,

abstracted and carried into distant districts, that are now parched and unproductive, there to create plenty; and the rivers, on reaching the lower plains, instead of impeding the construction of useful works, and destroying large tracts of valuable land, &c., would be found manageable, and merely furnishing those indispensable supplies of moisture which the culture of the earth requires.

"To accomplish this desirable result on the great scale required in India, however, the principle of canals for the transport of merchandise must be separated entirely from that of irrigation canals.

"A canal for mercantile operations is a very costly structure.

"A canal for merely conducting water, as a means of irrigation, is, on the contrary, a very cheap work.

"The revenue of India could not ramify irrigation to the extent required, either to fertilise the arid districts or to economise her enormous waters by the instrumentality of navigation canals, with all their costly locks, &c.

"By means of irrigation conduits, however, I have no doubt that the vast results I speak of might be accomplished fully, and at comparatively a very small outlay indeed.

"Canal construction, therefore, I feel convinced, should be limited to the principle of irrigation—irrigation conduits, with a view to the fertilisation of the soil, and the increase of Indian produce. For the interchange of that produce, and for all other public objects of locomotion, the most efficient and economical means will be found in a judicious application of railway construction.

DISCUSSION.

Mr. Hyde Clarke trusted that the important subject that Colonel Cotton had brought before the Society would not be continued as a discussion between the advocates of the East India Company on one side and its opponents on the other, nor between the advocates of railways and the advocates of other means of internal communication. If the subject be rightly viewed, if we looked at it under its moral aspect, if we looked at it with regard to the development of the resources of India, we must be convinced that its resources were ample, if properly directed, to carry out every means of internal improvement— it could scarcely even be a question whether railways should be undertaken in the first instance, or canals of irrigation, canals of navigation, tramways or other roads—whatever mode be adopted, it must result, as had been shown by the evidence which Colonel Cotton laid before the meeting, in the increase of the physical and material resources, and consequently, in the means of giving a reproductive return on the future works. It was to the moral results, therefore, that he conceived we must in the first instance look, rather than to the pecuniary results, and if we measured those results upon the basis which Colonel Cotton had given us, if we looked to the saving of life which was the result of any improved means of communication, to the extension of produce and the increase of resources, we must be convinced that we should have in that development the means of carrying out all the other branches of our undertaking. It seemed to him that the cause which Colonel Cotton had taken up, had been to some extent damaged by the comparison which he attempted to draw between canals and railways. He (Mr. Clarke) did not wish to examine it as a partisan of railways, or as an opponent of canals, because he was convinced on the one side, with Colonel Cotton, that canals, both of irrigation and navigation, were essential for the welfare of India, and on the other side he was convinced that rapid railway communication was one of the most essential means for creating a great moral reform in India. But looking at it under the commercial aspect, in which Colonel Cotton had chosen to examine it, it seemed that a very great fallacy lurked in the comparison which the gallant Colonel had attempted to form. He had taken the simple figure of the fare or cost of carriage by water, and he had compared it with the cost by railway, and the view which he had attempted to give had been that the simple cost of conveyance was the whole cost which arose on the article of production in its transit from the place of origin to the place of consumption—but when we formed a comparison between a river or a canal for instance, and a railway, we had other elements of calculation to take into account, and more particularly, where a railway was concerned, we must take the saving of time in its various bearings as a very important element. And if we took the great valley of the Ganges, through which the greatest line of railway was in progress, we should find that the mere saving of interest on the original cost of the article, formed a very appreciable item in comparison between the two modes of communication—but a comparison between railways and water communication became practically incapable of exact parallelism, because the railway could carry what the river could not. Take for instance, various articles of production which do not admit of a long water voyage. It was evident that while they were restricted to water navigation, those articles could only be consumed within a small circle; for instance, all those articles which, in our own experience, were perishable, such as butter, fruit, vegetables, and all those various articles which could only be consumed in the neighbouring market-town, were now carried to every part of the country—nay, he might say, to almost every part of Europe. The moment you enabled an article to be consumed, you created the means by which it could pay for its transit. Enormous as was the traffic of the great valley of the Ganges, it was nothing in comparison with what it would be if railway communication were introduced. Numerous articles which were now left to perish in the place of their production would be carried to distant places, and would of themselves constitute important articles of traffic—but even with regard to great articles of traffic, notwithstanding what the gallant Colonel had told us, there was scarcely one of them, however low-priced, that would not pay the expense of railway transit—and he was not speaking without some consideration of the subject—because, though we were told that railways were only projected for India five years ago, yet he remembered, himself, that he was, ten years ago, asked to investigate this question of the capability of railways to compete with canal navigation, by three gentlemen—Mr. Macdonald Stephenson, who founded the Bengal system, Mr. Heath, who founded the Madras system, and Mr. John Chapman, who founded the Bombay system.* Now, on looking into all the elements, taking into consideration the cost of the article at the place of its production and at its place of consumption, it was evident that the difference between the two prices was made up, not simply by the cost of transit on the Ganges, but likewise by the interest that was saved or lost on the other side, by the circumstance that the article could be brought to market under any conditions, and the fact that it could be carried to market in safety. Now, with regard to cotton the gallant Colonel must be perfectly aware that under the present imperfect modes of communication, cotton was subject to deterioration and loss in the course of its transit; so that though we might start with a cargo of cotton of a certain nominal weight, we should find, before we got it to market, a great quantity had disappeared, in one form or another. If carried by beasts of burden, the very animals consumed it if they could get at it; it was subject to injury on the river; it was exposed to theft on the road—whereas, in carrying it by railway, it was brought expeditiously to market, without injury, and therefore there was a greater gross return than there was in carrying the same article by an apparently cheaper mode of transit on the river, or on the canal. But there were likewise commercial considerations which would preponderate with the merchant, and would induce him to give a preference to the quick mode of transit. The mere fact that an article could be brought rapidly to the port of shipment would determine the question, whether it should be conveyed at all; it did not become a question whether it should be conveyed by

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*** Practical and Theoretical Considerations on the Development of Traffic in India. Weale, 1845.**

road, or by the Ganges, or by a railway, but whether it could be carried from the port of shipment to the market at the right season, or whether it could be carried at all. Therefore, instead of limiting ourselves to taking the cost of conveyance on the river Ganges, and the penny a mile on the railway, we must take into consideration the whole of those varied circumstances which influenced the producer and the merchant in determining whether they should deal in the article at all—but if we were to limit ourselves to this pecuniary investigation, and to determine whether or no we should give India a particular class of communication, because we thought rivers or canals were cheaper, we should evidently exclude that far higher consideration, the effect which a railway system would have on the development of intercourse among the Europeans and natives of that great country. If we only looked to what the electric telegraph had done to the present moment, chiefly for political interests, but which it would in a short time effect for commercial interests—we must acknowledge that a great lever had been applied to the moral organisation of India which would realise the greatest results. But when you could give the Europeans of India a means of communication with every part of the peninsula, you would thereby increase vastly their moral power. Government had been in the habit of looking at it with the view that it would enable them to use a smaller body of troops, because they could be readily moved from one garrison to another, and to the place where their action might be needed. But if we looked at it with regard to the moral garrison of India, that was, the English officials and the English residents in the country, we should see that the railway would extend their influence to a far greater degree than at present. We had been told by some of our Indian friends of the great loss of time incurred in travelling from one station to another. That loss of time and money must be measured by the loss to the natives of India. If the European community which, after all, was the great centre of civilisation in India, could be made more effective in its action, we might be assured that it would so leaven and excite the native community, that we should have the means of carrying out not merely the projects of the gallant colonel, but those of the railway gentlemen who had advocated their respective schemes during this discussion. But there was one very important economical consideration connected with the effect of the railway system in India. It was one which we might appreciate to a small extent by its effect in this country. If we looked at what was going on in the market towns, but still more sensibly in the western parts of Ireland, we should find complaints of the rise of prices of common articles of consumption, and also the necessaries and luxuries of life, originating in the fact that those articles were carried off to the great manufacturing towns and the metropolis, and we must observe that the effect was not the obtaining an average price between the low price which subsisted in the distant towns, and the high price which prevailed in the great towns, but it was a general raising of prices throughout the country. Now that was a result which we should certainly achieve in India, from the moment we could apply, not simply the ordinary means of communication, but good and effective railway communication throughout India. And see in what way this raising of prices would act upon the condition of the population—see how it acted in the west of Ireland. By the mere fact that you raised in their markets the cost of their articles of production, the agriculturists of Ireland were more easily enabled to purchase improved agricultural implements, and to exchange their products with the rest of the country. So long as the west of Ireland was in that condition that meat was 3d. and 4d. a pound, and the wages of day labourers 4d. and 5d. a day, they were not able to obtain a good exchange for their produce; but now that you had raised the value of their productions and the wages of the labourer, you had obtained great consumers for the manufactures of this country, and that was one great result which you would obtain in India and upon a far greater scale, because you had to deal there with upwards of 140,000,000 of people.* He would not detain the meeting longer in enlarging upon these points, because there were many gentlemen who could speak upon this subject much more ably than he could, but he had had an opportunity of considering many of these questions in connection with railways and telegraphs in India practically, and he should regret if a discussion so important degenerated into one between the advocates of particular modes of communication.

Sir FREDERICK ABBOTT remarked, this was the second time this very important and interesting subject had been under discussion before the Society, yet, he was sorry to say, they appeared to be just as far as ever from the point which they wished to arrive at. Col. Cotton had laid before them a very remarkable paper, in which he appeared to regard the increase of the means of internal communication in India as the great desideratum for benefiting that country, and, as far as he (Sir Frederick Abbott) understood it, Col. Cotton had laid down two propositions, in which all his views appeared to be condensed. First. That it was necessary for the welfare of India that they should pervade every district with a system of cheap communication and transit for goods; and second, that water was the only mode of transit that could be given to India with any sort of advantage.

Col. COTTON—As the main lines of communication.

Sir FREDERICK ABBOTT would refer to the gallant gentleman's sixth proposition, wherein he stated, "Nothing but canal or river communication can provide India with sufficiently cheap transit for its long distances and the small value of its main articles of transport."

Col. COTTON—As the basis of communication.

Sir FREDERICK ABBOTT—That meant that the trunk communication must be by water—flowing rivers or canals—which, in both cases, would require to be navigated by steam-boats of large capacity. Then he understood the lateral communications might be minor canals or railways, or by the ordinary country roads, made traversable from end to end by bridges. Up to this point the discussion reminded him of the proposition which Charles the Second put to the Royal Society of London in its early days, viz:—"Why a fish out of the water weighed more than a fish in the water?" They set to work to reason the subject, but never thought of putting the proposition to the test to see whether it was the case or not; and so it was with the present system—they had not tried to prove Col. Cotton's system to be correct. He thought the only mode to be pursued in endeavouring to come to a satisfactory conclusion on the subject, was to ask the gallant Colonel to answer questions that might be put to him as to the feasibility of the system of communication which he proposed, and if that proposition were acceded to by the chairman and the meeting, he thought they might arrive at something like a proper view of the case.

The CHAIRMAN was sure Col. Cotton would be happy to answer any questions put to him.

Col. COTTON—Quite so; any question whatever.

Sir FREDERICK ABBOTT—Then he would ask Colonel Cotton whether it was intended that the system should be applied to the whole of India, or whether it regarded merely the peninsula of India, and not the plain districts?

Col. COTTON—Upon this I have said, "All the districts, certainly, could not be improved in exactly the same way as Rajahmundry, because it is a delta, and has peculiar advantages both for irrigation and water communication, but they ought all to be improved on the same principle; thas is, *every advantage should be taken of the peculiar natural facilities of each district,* to supply it as quickly as possible with these two grand requisites—irrigation and cheap transit."

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* The railway and canal being simply a result of labour, the construction of public works in India becomes no longer a complicated question of capital, but a simple application of local resources.

Sir Frederick Abbott said, then he would ask where was the river that could be made navigable for steamboats of large capacity, to any extent? Then take the case of canals—either flowing or still-water. A still-water canal, in a tropical climate, would become clogged with weeds, or fœtid; therefore they must, in a country like India, resort to flowing canals; and when the action of the steam-boat wave was superadded to the erosive action of the moving water, the soft, sandy soil would never be able to retain the proper form of bed. These were some of the difficulties that had occurred to him with regard to Col. Cotton's plan, which could not be applied to the whole of India, but must be taken as applying to a particular part, and not to the whole country. He would ask Col. Cotton whether he applied his plan to any particular part?

Col. Cotton said, there were at present two large rivers navigable during the whole year round, the Indus and the Ganges; and had 10,000*l.*, or 1000*l.*, or even 100*l.* per mile been expended upon improving the other rivers of India, most important results would have been effected.

Sir Frederick Abbott—The Government is ready to do so if a favourable plan is laid before them. A celebrated engineer was sent out to make a project for improving the navigation of the Ganges.

Col. Cotton—I have been writing with all my might for the last twenty or thirty years to press upon Government plans for the improvement of India by means of public works, but I have almost invariably been snubbed, and I never got an opportunity of speaking out upon the subject till I did it here, and now I am ready to answer any question that may be put to me.

Sir Frederick Abbott would ask Colonel Cotton how he would control such rivers as wandered through wide beds of unfathomable quicksand, and make them navigable for steamers of large capacity.

Colonel Cotton had laid down a plan in the works that he had published. There were different ways for different rivers; but the main point was to do first what could be done in the beds, and the next thing was to store up water so as to increase the supply in the dry season.

Sir F. Abbott—"Store up the water of the Ganges!" Was there anyone here who had stood on the banks of the Ganges—

Mr. Davis objected to this catechetical style, and moved that this cross-questioning should cease.

The Chairman remarked that to pursue a system of cross-examination would be at variance with ordinary practice at these meetings. If Sir F. Abbott knew any objection to the views before the meeting, and would state them, he (the chairman) was sure that Colonel Cotton would reply to them when his turn came.

Sir F. Abbott would bow to the decision of the chairman, and would then briefly refer to one or two objections which occurred to him in the plan of Colonel Cotton. He had already said that the plan was to provide large trunk water communications for India. He was confident that in one part, including one-half of India, this could not be carried out. Water trunks of communication must be either canals or rivers. Canals might be of two kinds, flowing or still water. He would say that many of the rivers of India are of a nature that they could not collect the waters in sufficient body to form navigable streams for boats of large capacity. Colonel Cotton had said that large boats did navigate the Ganges; but he (Sir Frederick) had never seen any large steamers upon the Ganges. An engineer, who was well acquainted with the character of the Indian rivers, and had written much upon them, sent out a plan for boats to waddle, as it might be termed, over the sands when the water failed. Colonel Cotton's plan might be a very good one if the rivers of India were like the Mississippi. Mr. Ayrton had very correctly stated, that during three months of the year they were enormous floods, and for eight or nine months they were merely miserable streams. It was very different to the streams they were ordinarily acquainted with in England and America. Such waters might be easily collected and made subservient to the purposes of commerce by a little engineering skill; but what could they do with rivers whose beds extended over five miles of shifting sands. Mr. Simms had proposed the erection of groins, and he (Sir Frederick) had seen the plans of them, and whilst he was engaged both as military and civil engineer in the Western provinces of India, he found it would be cheaper to turn the whole course of the Ganges into one bed than to apply these groins; and that was not the worst. It was found that in the moveable banks of the rivers the groins would not remain, or that the river would form a new channel. Where they caught a river upon a rocky bed they might control it; they must then go to the rocky head of the river and then they might control it; but then the supply of water in most cases would be very limited and insufficient to carry steam-boats of large burthen—he meant in the peninsula of India. He could understand that it might be so—in a hilly country; where we caught the river between rocky banks, we could control its waters and turn them where we pleased. In such a country, too, where the chief obstacles to navigation consist of interposing rocks, any judicious expenditure of money would produce a certain and a permanent effect. But how could the same remedy be applied to the plains of India—to that vast region extending from the Indus south-eastward to the Burhampooter river, from the Himalaya Mountains southward to the Vindhaya range, a tract of country comprising more than one-half of our Indian possessions. There the case was entirely different. There we could not control the rivers which, during eight months of the year, meandered in shallow streamlets.

Mr. Carnac Brown would call attention to the observation which had been made, that the rivers of Upper India were unsusceptible of canalisation. He thought that was the purport of the observations of the last speaker. He would ask whether one of the greatest achievements of the present age, both as to magnitude and as a work of art and science, did not consist in the diversion of a portion of the Ganges into the Great Ganges Canal, which was accurately described to them at the last meeting as being 850 miles in length; and he would ask whether that was not a canal of irrigation as well as of navigation.

Sir Frederick Abbott—Not for steam-boats of large capacity.

Mr. Brown said it was no answer to the general proposition, to say that large steamers did not ply upon that canal; but there was a case in point, that a river in the country of which the gentleman who last addressed them had spoken was susceptible of canalisation. With regard to the other part of the proposition, he would ask whether the Punjaub, the country of the five rivers, was not capable of being intersected, from the base of the Himalayas to the Indus, by canals drawn from these rivers; and yet they were told that the provinces of the upper part of India were not susceptible of canalisation.

Sir F. Abbott was perfectly aware that canals could be made in Upper India; he had been associated with many such works, but he contended that these canals could not be made navigable by steam-boats of large capacity on the canals with which he had dealt. The rivers which fed them were diverted from their channels as they broke through the lower range of the Himalaya chain, but the supplies generally were not sufficient to give navigation for large steamers. Lord Ellenborough objected to sanction the Great Ganges canal unless Sir Probus Coults would promise to render it navigable for steamers to Allahabad, which could not be done.

Capt. Andrew Henderson said, allusion having been made to the desirableness of confining the discussion to the means of developing the resources of India by the diffusion of information based on experience rather than theoretical schemes or controversy as to plans or routes proposed, he was induced to follow the former course by the deep interest he felt in this important question, from having been upwards of twenty years in India engaged in maritime enterprise, unaided by Government. And since his return to this country he had participated in most of the practical efforts that had been made to establish steam communication throughout the Indian seas, on the Hoogly, Ganges, and Burhampooter, and to the cultivation of tea, and its transit from the upper branches of the latter river to the consumer in England ; also in the improvements of the harbours of India, and the facilities afforded to trade by dock accommodation. The subject might be divided under three heads. First. The works on the Godavery in reference to irrigation and communication, which were more particularly the subject of Colonel Cotton's paper. Second. Other public works or private enterprises tending to develop the resources of India and improve communication. Third. The mode of carrying out those works, whether by Government or private enterprise. The valley of the Burhampooter afforded the same field for improvement to the Bengal Government which the valley of the Godavery did to the Madras Government, as the difficulty experienced in the former case might be useful in preparing for the latter. Fully concurring with Colonel Cotton in the very great advantage that must accrue to India by the extension of the means of transit, either by rail, steamers, rivers, or canals, from his own experience he doubted the immediate applicability of any one system to the valley of the Godavery, or other rivers where there was no existing traffic. The cotton and produce of these valleys found a market at Bombay and Mirzapore by costly land-carriage, but the cheap river transit calculated for the Godavery could only be attained after years of experience and improvement of the river, and an actual *creation* of the traffic that was to flow along its banks, *i. e.*, to divert it from the present land route to Bombay and Mirzapore to the valleys of the Nerbudda and Godavery, with ports at Surat and Coringa. He understood the basis of Colonel Cotton's proposal to be, that the cotton of Berar now costs 6*l* per ton for land carriage to the sea-board, and that it could be conveyed for 10s. a ton by the Nerbudda or Godavery being made navigable for some 500 miles to the port of Surat on the west of Coringa on the east coast. Against this, the advocates of the rail allege that cotton could be conveyed by railroad at some 14s. a ton—160 miles to the port of Bombay in eight hours. There might be a certain amount of truth in both these propositions, but the question of transit could only be met by a combination of both, *i. e.*, the use of river navigation as high as was practicable, and the construction of a cheap line of railway from the point where the navigation ceased. Colonel Cotton was perfectly right in saying that none but the very cheapest navigation would do. What he (Captain Henderson) was afraid of was, that gentlemen who supposed that we were to have a railway at once, were reckoning without their host. We must give time for the trade to be developed—you must first of all get ports to get rid of it. What was the use of having a railway up the valley without a port to take the produce to? It was absurd to talk of expensive locked passages for vessels; when a navigation was available from its natural state, or where a very small expense would put it in good repair, it would be, of course, right to use it. The attention of the Indian government should be directed to the improvement of places actually navigated. We were constantly hearing of difficulties attending the navigation of the Hooghly below Calcutta, and even the monstrous idea of a ship canal, 24 miles in length, had been proposed. Under the second head, he should wish to allude to many works, the undertaking of which he had himself been interested in, or in which he had taken an active part; and, as in the case of the Assam Company, he could but refer to the little encouragement the Indian government had given—a policy he hoped now to be mentioned only as of the past. One of the first of these was a proposal made, in 1838-39, by the East Indian Steam Company, to maintain a complete system of steam communication with the presidencies of India, with vessels of 2,000 tons, if guaranteed 100,000*l.* a year, or 6s. 6d. a mile, by the East India Company. The Court of Directors replied, that to any well organised extension of steam communication they would give support; on the faith of which he conducted the steamer Indus to Calcutta, and opened steam communication with Suez; eventually, the Peninsular and Oriental Company obtained a large grant of 115,000*l.* a year for performing work very much less than the service that was proposed by the East Indian Steam Company. The East India Company relinquishing all control to the Admiralty, Indian steamers were refused all participation in the trade, and to steam enterprise the revenues of India now contributed seven-sixteenths of a payment of 160,000*l.* a year to the Peninsular and Oriental Company, for eight years, and of 199,600*l.* the next ten years. This monopoly of public support effectually ruined every Indian steam enterprise, the East Indian Steam Company of Calcutta being refused any compensation for some 40,000*l.* losses incurred in first opening steam communication with Suez, although an appeal was made to the Court of Directors and Board of Control. In 1838, the East India Company wishing to develop the resources of the Burhampooter when they had relinquished the monopoly of their tea trade, commenced the cultivation of tea in Assam, and spent some 60,000*l.* or 70,000*l.* in maintaining a Government establishment for the purpose of carrying on the tea trade; after that they handed over their establishment to a Company, which laid out 200,000*l.*, and, in short, went a-head too fast, their operations being based upon calculations such as were now before us about the Godavery. But what he wanted to show were the practical difficulties that we found there. We had there a splendid navigable river; we were told that steamers of four feet draught of water could go 1,000 miles up, and that the place was full of timber. What was the result? Why we sent the appliances before the trade was there. According to the Company's officers' reports, they told us that in five years we were to have 2,000,000 lbs. of tea; that would be somewhere about 3,000 tons. We thought that we must send a steamer and sawmills to cut the timber; they were both sent there, at an expense of nearly 30,000*l.*, and they were of no use whatever. The consequence was, that the sawmill was put on one side for ten years, and the steamboat was taken off; and after we had been fifteen years at work, we were in the best position that any enterprise could be in. At our general meeting the other day, we had a clear profit of twelve per cent., and this had been by patiently following out the experience that could only be obtained at great cost. In this instance, loss of interest might be estimated at 60 per cent. on 194,000*l.* capital invested 15 years, the Indian Government refusing all aid, even to a participation in the cost of many hundred miles of road made. Had they guaranteed the interest at 5 per cent., as now adopted with railways, it would have amounted to 116,000*l.*, to be repaid when the profits exceeded 5 per cent., which, in the Assam country, must occupy 5 to 10 years. In 1840, he took part in the formation of a Company to cross the Hooghly at Calcutta, with steam ferry bridges, similar to those now at Portsmouth. Two of these were landed at Calcutta in 1842, but the enterprise could not be carried out from the want of support from Government, and from other causes. The bridges, engines, and chains, which cost 37,000*l.* were sold for 7,000*l.* The same mode of passing that river must, he believed, be eventually carried out, the large traffic from the north-west rendering it absolutely necessary, whilst the difficulties attending the construction of a fixed bridge were, he believed, insuperable. He proposed in 1850 the construction of piers, graving-docks, and a railway, from a land-locked harbour to

Singapore, as a naval station for the Indian seas, if guaranteed the interest on 100,000*l.*; but here again they met with no response from the authorities, although the value of such a work could not be denied. From the likelihood of war, the attention of the Indian Government had been turned to this harbour, as well as to Basseen, near Cape Negrais, in the newly-acquired province of Burmah. Works were in progress to improve the bar of the Godavery at its port Coringa, which was most important as the Madras coast was, destitute of harbours. On the coast of Western India, there was a field for improvement in the harbour of Surat on the Taptee and Kurachee on the Indus. Lastly. He might venture a proposal to form wet docks at Calcutta, a question which he brought forward in 1843 and in 1844; it was taken up by the Indian Government. They appointed a committee of Government officers and merchants, who, in 1846, reported the practicability of constructing docks for 200 ships, at a cost of 500,000*l.* The site recommended was below Calcutta, on the left bank of the Hoogly, the railway station being formed opposite Calcutta, on the right bank of the Hoogly. Experience showed that docks should be connected with railways. A proposal to this effect was submitted to the Government of India and the Court of Directors, to construct docks near the railway station at Howrah, and to connect them with the steam ferry bridge, if guaranteed the interest on a capital of 600,000*l.*, which was now under the consideration of the Government. There were great advantages in India being under a form of government which could decide peremptorily on the best mode of doing things. Here in England divided interests had caused an absurd and useless expenditure of money. Everybody allowed that greater conveniences in modes of transit could now be obtained for half the money, if the Government had demanded and enforced a system. This was no excuse for the Indian Government, so far at least as a proper system for the execution of public works. The existence of a new Board of Public Works in India was a step towards the fulfilment on the part of Government of at least some of this. And this led to the question of the *mode of carrying on public works in India.* There was a general feeling among Englishmen in favour of works being carried on by joint-stock companies, but, at the same time, a strong feeling on the part of the British capitalist not to invest money in India. This arose in a great measure from the want of interest in Indian subjects, a feeling that they had no direct mode of controlling the actions of the Indian government, *i.e.*, in matters which might affect the profitable employment of capital. And this would point out the necessity and justice of guarantees in all public works. Public works should be reported on and decided by the Public Works Board. To explain the relation mentioned between the necessity for a guarantee and the political action of the Indian government, a government which was responsible for a vast sum yearly to various companies, must always be cautious in those movements of peace or war, which might affect the profitable result of those companies, and indeed this was the only mode which an English capitalist had of controlling the Indian government to his own interests. If public works were to be carried on by the Indian government, there should be a system organised for the employment of the vast army or a part of it, in a manner similar to the old Roman legionaries. There was an inconsistent action of the Indian public and press, on the question of government executing public works; if government did nothing there was a great outcry, and if money was raised, the holders of other government securities spoke of it as a "scandalous action," and as "base and unprincipled." Doubtless the Indian government would jog on as it best may, and do its duty, but these facts all pointed to the advantage of carrying on public works by means of private companies, guaranteed a rate of interest proportionate to the value of money at the time that the company commenced operations in the particular work for which it was formed.

Mr. Dickinson wished to point out one or two facts connected with Indian communications. One sentence of the last speaker would bring us to our point. He said that Colonel Cotton stated that you might get to the interior of India and get the cotton from Berar at the rate of 10s. a ton, and that the railway gentlemen, on the other hand, said they could bring the cotton from the same distance for 14s. Now let us see how far this was true. The other night we had a gentleman connected with a railway—the managing director of the Bombay railway—who told us that his railway was sanctioned to Malligaum, the centre of Berar, 160 miles from Bombay, by which he could bring this cotton from the centre of Berar to Bombay for 14s. At the present time, according to the report of his own railway company, published the next day, his railway was *not* sanctioned further than the foot of the Ghauts, here at Shawpore, Malligaum being in the centre of Candeish, Berar being there (pointing to the map), 250 miles away. That was rather an important fact. Colonel Cotton had proposed to improve this river (the Godavery), and he (Mr. Dickinson) had recently seen a report by a very first-rate engineer upon it in India, in which he said that he could improve the Godavery as far as it was requisite, making tramways up the remaining distance to the very centre of Berar, about 80 miles, he believed, for a comparatively small sum, very little more than 500*l.* a mile, and that he would do this in a single year. We had been recently led to expect that we should have peace, but it appeared by the second edition of that day's papers, and by the receipt of intelligence from the Continent, that we were no longer so certain of it. Now, bearing this in mind, it was important to consider that you could have wheat from the centre of India at a wonderfully cheap rate. There was a gentleman present who had frequently shipped produce from Berar, and had taken boats up both the Nerbudda and the Godavery, and he could corroborate him when he said that you could get any quantity of wheat at 12s. a quarter in Berar, and it could be brought to Liverpool at an excessively cheap rate. Now he thought this would become a very important question, or rather it was so at present, looking at the high price of wheat at this time. Then, another advocate of the railways said the other night, that Colonel Cotton had entirely left out of sight that the rivers on the western side of India were wholly unnavigable. You might see marked on the map the line of the Syudhnee range from Cape Comorin, stopping at these two rivers. The Taptee was not navigable, but with respect to the other river (the Nerbudda) he had a report from one of our political agents in the country, who implored the people of this country to get up a company to navigate the Nerbudda, stating that a native chieftain, Holkar, had already a steamer upon the river, which would hold 100 people easily, and he remarked upon the facility with which the natives seemed to manage the machinery; and he said he had another steamer 250 miles up the river, towed up all the way over the falls, which might very easily be converted into a navigable channel. Now, with regard to the general subject of India, there were one or two other things which we were told the other night—we were pointed to the Bhore Ghaut, and told that there was only one gradient of one in thirty-eight, and that was nothing after the Lickey incline near Bristol, in which you go up nearly a mile with a gradient of one in thirty-seven.

Mr. Nicholson.—The Lickey incline is three miles long, and it is one in thirty-six.

Mr. Dickinson continued.—Here was the report of the Bombay Railway, stating that by successive surveys they had found such an incline upon the Thul Ghaut, and they hoped, upon further investigation, to find such another upon the Bhore Gaut. It was very important to observe that it was not on this line intended to tap the cotton district, for the meeting were led to understand the other night it was so. The same gentleman got up the other night, and drew a plan on a board, of which he supposed the map before the meeting was a more perfect representation, with all these lines, saying, " There, gentlemen, all that railway system is sanctioned! There are 4,000 miles—what can the government do more, and what can you wish for more in India? " In the first place he was sorry to say he had to contradict some of those remarks. He stopped the Great Indian Peninsular Railway at the foot of the Bhore Ghaut, to begin with; for by their own report it was sanctioned no further than Shawpore; that it was not sanctioned into Candeish, and that Lord Dalhousie wrote a minute, recommending this railway system, because he wanted to do something that should satisfy the public over here; he found it necessary to say that there should be a great system of railways in India, and that it should go generally in those sort of lines; and those sort of lines generally had been commenced, and companies had been sanctioned to begin railways upon them. In one case 100 miles had been sanctioned; in another, 120 miles, and about a thousand on the line which ran parallel with the Ganges; but the whole system, as laid down on the map, was not sanctioned. There was, however, a bit sanctioned that was not laid down, viz., the Bombay and Baroda line to Surat, which *is* sanctioned. He did not know why that was left out. When we got to Surat, however, it became again a question, how were we to get this cotton and wheat from the interior of India? At the present time we felt exceedingly uncomfortable about the possibility of the annexation of Cuba. Even if there should be a short crop in the United States we should be exceedingly puzzled to get on in this country without this Indian cotton. The question was how to get at this district. Colonel Cotton had said that for very distant traffic you could have nothing but water-transit. Dr. Lardner had previously said that the distant traffic of America was entirely conveyed by water. Now, the Indian press was so mistaken upon this subject that it said the railway traffic upon the Indian railways must wait until they got a few hundred miles into the interior for us to be able to judge of their capacity of carrying traffic; but when they did so they would never be able to carry cheaply enough to convey the long traffic down to the coast. But there was another point. Those railways had been suddenly sanctioned by the Indian government to silence the clamour in England with regard to communications in India. The clamour which arose in 1844 was silenced in the same way. They then started two lines, and he should like to show the meeting what one of those lines had done, because he was always told when he came to these railway affairs that so and so would be opened, and so and so would be done. Now, what had actually been done. In the *Indian News*, August 15th, 1854, there was an article on the Bengal railway, showing that supposing them then to have made 100 miles of railway, and to have half a million sterling in hand, which was perfectly well known was not the case at that time, they would then have spent 20,000*l.* a mile in a country presenting no engineering difficulties, without having anything to pay for the land, and incurring no parliamentary expenses—and this in a country where money was stated by the directors to be worth seven times as much as in England; that was to say, they spent a sum equal to 140,000*l.* a-mile. Now, what had they done for that? The other day they had opened a bit of it, and they had spent now about 3,000,000*l.*, equal to 21,000,000*l.* sterling in this country, and they were said to have opened up to this time 66 miles of railway, from the Calcutta terminus to Burdwan. He took this from the newspaper which recorded the inauguration and opening of the railway to Burdwan. We wanted something very much more cheap and speedy to open India, than these railways. We had 32 miles open on one side, and there were 17 more in progress to Shawpore. If that was all we could do, he really saw no help for it at all. It was a hopeless case. What we wanted literally, was thousands of miles a-year. When it was considered that this country was as large as the whole of Europe, we wanted hundreds of thousands of miles of main communications, to have them in the same proportion as we had them in Europe. As he had not heard the statement of Colonel Cotton, and his calculations with regard to the difference of price between water and land transit disputed, he must assume that water transit was incomparably cheaper than land transit, and in that case it was obvious that one of the best modes of opening India would be to open these great rivers. In the case of the Godavery Delta, it immediately gave rise to a transit company, which paid in the first year 20 per cent. dividend, carrying for the eighth of a penny, which he thought the railways would be puzzled to do. It was the interest and duty of England to begin with this water communication. Nothing of the sort had been done hitherto. On the contrary, the water communication had been systematically discouraged, and a case was brought before the public only the other day, in which the canals which brought the traffic to Calcutta had been neglected for a series of years, till the boats could hardly get through them at all.

Mr. Cornelius Nicholson, having been so pointedly alluded to by the gentleman who had just sat down, begged to be allowed to offer a few observations in reply, and he would refer them to the map upon the wall in order to make his case quite clear. The meeting had heard that gentleman's correction of an error into which he (Mr. Nicholson) had unwittingly fallen at the last meeting with regard to Malligaum being situated in the cotton field of Berar. He found on further examination —having addressed the meeting on the former occasion in an unprepared manner—that Malligaum was in Candeish; but he contended that, although he had made a geographical misstatement, yet, in reference to the article of cotton, that it in no way shook or affected the *facts* of the case, because the question had arisen how the cotton of Berar was brought through Malligaum to Bombay. He knew at the time he was speaking that Malligaum was a large cotton district, that large quantities of cotton was sent thence to Bombay. Malligaum, as would be seen, was situated at the junction of the two lines of railway— the main line and the branch which went into the Berar cotton district. He would put a parallel case to them. Suppose, instead of being in London, they were in India, and instead of discussing the article of cotton they were discussing the transport of iron in England. They were accustomed to speak of iron as coming from the Staffordshire districts, and in his observations he had selected Birmingham as a centre. But, then, the gentleman opposing his facts, got up and said, " There's a pretty sort of man to discuss this question, when he does not know that Birmingham is in Warwickshire, and not in Staffordshire at all, and, therefore, nothing that he has said can be depended upon." Birmingham was not in Staffordshire, and Malligaum was not in Berar; nevertheless, nearly the whole of the Berar cotton comes through Malligaum to Bombay on the backs of bullocks, by hackeries, and other means of slow transit. Mr. Dickinson had twitted him upon the statement which he (Mr. Nicholson) made on the last occasion, that the Government had sanctioned these 4000 miles of railway. What he said was reported in the *Journal*, namely:—" To the great and lasting credit of Lord Dalhousie, since he had held the office of Governor-General of India, a grand system of railway communication had been laid down, which had received the sanction of the authorities at home, and was now in course of construction." He had stated that in broad terms, and he repeated it; for it was a known fact, that Lord Dalhousie had laid down in an official report this great system of communication; and, with regard to the 4000 miles, since the last discussion on this subject he had measured the entire distance, and he found he was quite correct in representing that that system of railway communication for India had been projected, and those lines he pointed out on the former occasion.

Five separate companies were proceeding with the surveys and construction of these lines—the surveying engineers were now spread over the whole district, from Bombay on the west, to Calcutta on the east, as well as the surveys of lines which would connect the two Presidencies of Bombay and Madras in one unbroken communication. He, therefore, thought he had fully established the truth of what he had stated with regard to the railway communication already sanctioned and in progress. He would now say one word with regard to the cotton. Col. Cotton had spoken of the production of cotton in Berar in a way, from the beginning to the end of his paper, to lead to the impression on the minds of those who were uninformed on the subject, that the Berar cotton field was *the* (only) cotton field of India. And the gentleman who had just spoken, and who appeared as the disciple of Colonel Cotton, had taken up the same line of argument; for when he (Mr. Nicholson) spoke of the Bhore Ghaut being surmounted at a gradient of 1 in 38, Mr. Dickinson got up and said, "Oh! that has nothing to do with the question, inasmuch as by the Bhore Ghaut you do not take a line of railway into *the* cotton fields of India." He begged to tell that gentleman that there was a large cotton field beyond the Bhore Ghaut, as well as over the Thul Ghaut, and they must not make a communication to one cotton field merely. He would give them, with permission, an account of the quantity of cotton exported and re-exported from Bombay in the year 1853. The total quantity, from different and distant parts of India, was 217,430,000 lbs. There were brought through the British Concan 75,500,000 lbs.; from Guzerat, 79,000,000 lbs.; from Scinde, 22,000,000 lbs.; from Darwar and Sholapore, 41,000,000 lbs.; and from the Coromandel Coast, 45,000,000 lbs., making a total of 217,500,000 lbs. brought to Bombay in 1850. Therefore, when they spoke of Berar, it only produced one-fifth of the cotton of India, and it would not do to expend all the money for public works in the construction of one line of railway, or in opening out one communication. They would find it stated in Colonel Cotton's paper that Berar produced 30,000 tons of cotton per annum, which was equal to 67,200,000 lbs.; therefore, if Berar was to have credit for 67,200,000 lbs. of cotton, it was clear to demonstration that the Berar cotton, according to the gallant colonel's estimate, included that from Candeish as well. If, therefore, he (Mr. Nicholson) was wrong in fixing on a depot too much to the west, Colonel Cotton was equally wrong in fixing on a central depot too much to the east. That which was considered to be in the centre of the two districts was Kamgaum, to which place a railway was being laid out, and could be constructed, Kamgaum being about 300 miles from Bombay, and the cotton being brought at a penny per ton per mile, the whole of the Berar and Candeish cotton would be brought to Bombay for 25s. per ton, and if they could do it at that sum in sixteen hours it was more than could be done by Colonel Cotton's river communication. He wished it to be understood that he did not in any way decry river communication. It might be a great and valuable adjunct to the railways, but if they could bring cotton for 25s. per ton, that was, he thought, a mode of communication preferable to the opening up of the Godavery—as part of the cotton would then still have to be carried on the backs of bullocks, or by other means, between 100 and 200 miles to the nearest point of the river where it was navigable. He, therefore, humbly represented that railway communication was, for main lines, superior to any water communication, and they could carry railways where water communication was wholly impracticable. He would conclude with one further observation as to what Colonel Cotton had said with regard to railways not being adapted to carry goods in India, and he stated that the most carried on any railway in England—

Colonel Cotton—I did not say that. I say you cannot carry 5,000,000 tons of goods by railway.

Mr. Nicholson—The gallant gentlemen said they could not carry 5,000,000 tons of goods by railway. He would show them that they could. Colonel Cotton had given 400,000 tons as the largest amount of goods carried on any railway in England, as he would quote from the printed paper:—"The most crowded railway in England only conveys about 400,000 tons." "On the East Coast of England, 3,500,000 tons of coals alone are conveyed, and, *probably*, 8,000,000 or 10,000,000 tons of *goods* IN ALL, while on the Great Northern Railway only 400,000 tons, as before stated, are carried." He (Mr. Nicholson) had been, that morning, to the offices of the London and North Western Railway, and had obtained returns from their books, which showed that during last year 5,114,259 tons of goods, merchandise, and coals, were carried on that line! That was thirteen times the quantity of goods traffic that Colonel Cotton said had been carried on any railway in England.

Mr. Beardmore asked how many miles that had been carried?

Mr. Nicholson—500 miles, or more; but only *half* the length of the Bengal line.

Colonel Cotton said this was a remarkable point, and, perhaps, he might be allowed to notice it at the present moment. The railway returns constantly gave an account of so many hundred thousands, or so many millions of tons of goods conveyed on the line; but what did that mean? Did any one know? He was sure the gentleman who had just addressed them did not know. The railway mentioned was in fact a vast system of railways, of 640 miles in length. This was the total number of tons of goods entered for conveyance on those railways—some being carried to places 20 miles from Euston-square, and others to more remote distances, but the average receipts for goods, as stated in the railway returns, gave about 29 miles as the average distance which each individual ton of goods was carried; thus, upon a line of 640 miles in length, the goods were carried on an average 29 miles each ton, or about a thirty-fourth part of the total length of the railway, and, if they calculated, they would see that the average quantity over each mile was 200,000 tons exactly. When he was speaking of what a railway could carry, he spoke of the quantity of goods that passed over any one part of the railway—not 20 miles here and there, and added up upon the whole length of the line. He repeated that the average quantity carried over each mile in the case mentioned, was 200,000 tons.

Mr. Nicholson said that explanation did not meet the case he had quoted from the paper.

Mr. R. W. Crawford said he had very little privilege to address the meeting, because he was not present on the former occasion, when this subject was brought under discussion. In fact, he hardly knew upon what the discussion was, as it had received very little elucidation from the turn which it had taken that evening, but he would offer one or two remarks with reference to the East Indian Railway, with a view to dispel any erroneous notions that might have been formed with regard to that undertaking. Mr. Dickinson had stated that 66 miles of that line only were opened. It so happened that the number of miles at the present moment in active operation was 122, and the number of miles which the company were under contract to complete was, he believed, 946, or at all events between 900 and 1,000 miles. They were under contract to complete and deliver over for the public use, in entire operation, the whole of that immense line before the end of the year 1860; and so far did the public in India sustain the company in their endeavours to that end, that contracts had been entered into for the execution of the earthworks which would complete the whole distance before the end of the year 1857. He maintained that whatever might be the opinion of some persons as to the extent to which railways had been constructed in India up to the present moment, there was a great prospect of an enormous system of railways being in active operation there before many years were past; and his own experience of that country justified him in assuring this meeting that the amount of traffic would be to an extent and degree which the people of this country were hardly able to appreciate. With reference to the cotton districts on the western side of India, it was true, as stated by Mr. Nicholson, that there existed a large cotton-field there, which the proposed railway connecting Bombay and Madras was intended specially to serve. And there was another point which he thought had been a little overlooked, that was, that as the traffic of that part of India at the present time was carried on almost entirely by animal power, and as one of the limits to that traffic was the limitation of the animal power, so when these railways were opened an immense number of beasts of burden would be set free from their present occupations, and would contribute very largely to carry on communication between the places in the district where the produce was grown, and the lines of railway as they were gradually opened up. A gentleman had stated that wheat could be obtained at 12s. per quarter in the neighbourhood of the Nerbuddah, but he (Mr. Crawford) believed he was correct in stating that it might be purchased at a cost of 9s. per quarter, and even for less than that: and he had no doubt that when the railway of which Mr. Nicholson was the managing director was in operation, a large amount of wheat, linseed, and various other productions of the country, would be brought upon that line. To talk of canals in that part of the country, there were not the means to make them; and as to the Nerbuddah being made navigable, and the gentleman who had sailed up and down the Nerbuddah, if he had sailed on it for any useful purpose, and with any good practical result, he (Mr. Crawford) would be exceeingly glad to find such had been the case.

Mr. R. F. Davis remarked, that gentlemen evidently came there with preconceived notions, and instead of discussing the best means of developing the resources of India, it amounted at present to a discussion between the managing director of a railway in India, as to this, and the secretary of the India Reform Association, as to that; while, to use the language of Burke, " the subject which embraces all mankind is given up to a mere party." The subject before them was the benefit of India. Col. Cotton had stated certain plans. Those who knew Col. Cotton knew that he was, as all men must be more or less who set themselves down to work a great reform, a man of determination—a man, to some extent, of one idea; and following out that one idea, if he had gone a little too far to suit the notions of some of them, they were not, therefore, to say, " all was wrong—and this is the only way;" and because they thought they had got something a little better, to decry the plans of Col. Cotton altogether. The common-sense view of the question was this—there was a saying now very much in use—" the right things in the right places." He had studied India a great deal. He had many friends resident in and largely connected with India, and although he had not a practical acquaintance with the country, yet, having as he had said, studied the subject for many years, he had come to these conclusions—that India required improvement in her water communication to the utmost extent possible—improvement in her country roads. There was a specimen of those roads before them [pointing to an illustration of the present condition of roads in India on the wall] — improvement in communication by means of railways. He was himself a warm advocate of railways in India; but when gentlemen got up and said—nothing but the East Indian Railway, and nothing but this or that would do for India, and all that Colonel Cotton had advanced was wrong, he (Mr. Davis) came to the conclusion that those gentlemen were all wrong themselves. The gentleman who spoke last had said that when they got railways in India they would set a large amount of animal power free. He (Mr. Davis) was quite aware of that; but whilst they were speaking of railways for India, they must regard them with different eyes to what they looked at them in this country. On the other side of the Atlantic, they did not find Brother Jonathan laying down railways through what were once trackless wastes, but now smiling homesteads, with rails of 60 lbs. or 80 lbs. to the yard, but the object there was to lay down cheaply-constructed railways, and to bring them into operation as quickly as possible. That was what was wanted in India; instead of laying down 200 or 300 miles of railway, at a cost of 20,000*l.* a mile—

Mr. Crawford—10,000*l.* The East Indian will be made for that.

Mr. Davis believed that as much as 3,000,000*l.* had already been spent upon 127 miles; and, he believed, the cost would be nearer 20,000*l.* per mile than 10,000*l.* What the people of India wanted was cheaply and expeditiously constructed railways, and he would say, the man who introduced cheap railways into India would be a benefactor to that country. They did not want 300 or 400 miles of railway, to go at a speed of 40 miles an hour, but they wanted thousands of miles of cheap railway, to go from 10 to 15 miles an hour, which was quite fast enough for any purposes in India. It was very well to say that any particular part was the centre of the cotton district; it was, in fact only the depôt, and the quicker they made the railways of the kind he had advocated, the sooner would they get the cotton, the wheat, the rice, and the other productions with which India was teeming, which we in this country were very much in want of. One gentleman had said, that canals could not be constructed, but they found that that gentleman was running his head against something which Col. Cotton had not said. The question of large steam-boats on the canals had been introduced, which idea, it seemed, had not entered into the mind of Col. Cotton in the consideration of this subject. The object of the gallant Colonel was not merely to span the rivers with bridges, but also to carry fructifying waters to those parts where they were needed; and he (Mr. Davis) considered that canals in India ought to be encouraged to the fullest extent possible, as works of communication and also of irrigation. Col. Cotton had been twitted with the remark, that in this and that district it was impossible to construct canals; and no doubt Col. Cotton had never sat down to entertain the idea of carrying canals over the mountains. But what Col. Cotton said, and what he thought they must all agree with, was that the Government had been lax in carrying out public works in India. After repeated goadings from the public, they at length gave their sanction to a certain system of railway. He (Mr. Davis) called upon the Government to do the same with regard to the rivers of India, in order to give communication of all kinds with the interior of the country. He called upon the Government to spend the public money also upon works of irrigation, and not to spend the whole of the public money upon these great lines of railway. If they could assemble in that room the more intelligent portion of the people of India, he was sure they would say, "Don't give us 40 or 50 miles of high-speed railway here and there, but give us thousands of miles of cheaply-constructed railways, to go at 10 or 15 miles an hour." The public money had been spent upon one grand project, which, he contended, was not suited to the peculiar wants and requirements of the country. They called upon the Government to improve the river navigation, to improve the canals, to improve the irrigation, to improve the means of internal communication, and not to exhaust the pecuniary resources of the country in a project which was not adapted to the land in which they lived.

Mr. Ayrton presumed that the gentleman who last addressed the meeting had never been in India, or he thought he would not have displayed the facility he had in devising plans for the advantage of the people of that country. The gentleman had, in a manner, come forward as the representative of popular opinion in India; but he (Mr. Ayrton) thought those who knew him would, perhaps, regard him as a better exponent of the opinion of the natives on these matters. He would mention one circumstance, to give them an idea of what their views were. He believed the largest original shareholder in Indian railways, either here or in India, was a native of that country, Sir Jamsetjee Jeejeebhoy, whose capacity to appreciate any project for promoting the welfare of India he would place in the scale against that of the whole school of Young India; in fact, the subject of railways in Western India was taken up by those who had advocated them in Bombay, not as a matter of speculation, but entirely with a view of benefiting the country, and all the principal native and English merchants in Bombay had co-operated in the undertaking. He had imagined that he was invited to attend these meetings because he was supposed to have studied this subject, which, in fact, he had done, having taken it up before any movement was made on the part of the Government, in order to impress upon the Government its duty towards the public of India, and, at that time, now about 10 years ago, he rather startled people by saying the time was not far distant when the Government must be prepared to spend millions of money upon railways in India. He was thought to be an enthusiast, and speaking at random, but the result, even in that short space of time, showed that he was not far wrong, for they found that a sum of no less than 17,000,000*l.* had been guaranteed by the Indian Government for railway operations in that country. It was a mistake to suppose that these enterprises could be wholly carried on without the support of the Government. It had been tried and failed. It was not Mr. Chapman who first suggested the idea of railways for Western India, although he originated a company during the railway mania here, but Mr. George Clarke, a civil engineer in Bombay; and from that time forward communications were carried on with the Government, pressing the subject upon its attention. The promoters of railways had only considered what was best for the people of India, and the natives having the largest commercial dealings and the greatest knowledge and experience of the wants and circumstances of the country had duly appreciated their efforts, and, therefore, he was surprised at a gentleman bringing before a learned and scientific body like this, not only positive propositions for districts with which he was no doubt acquainted, but negative propositions for districts of which he probably knew nothing. He would call attention to one or two points in the gallant colonel's paper, to show how lightly he had arrived at his general conclusions.

Colonel Cotton—I have taken 30 years to arrive at them.

Mr. Ayrton—Certainly no conclusion with regard to the Indian railways could have been come to, or thought of, 30 years ago. It was stated in the colonel's paper, that transit by steam on canals would be the most economical means of conveyance. Now, it would be found that steam navigation already existed, under the most favourable circumstances, on the Ganges, but it appeared, by the list of rates in the colonel's paper, that the cost of steam transit in the Ganges was 3d. up the stream, and ¾d. down, making an average of nearly 2d. per ton per mile; and on the Indus, for 500 miles, there was a charge varying from 1½d. to ½d.—making an average of 1d. per ton per mile. If they found, so far as steam navigation on rivers existed, the cost was as he had stated, it was, he thought, a bold assumption to say they could make other rivers navigable, and that the cost would be less. He thought the cost would rather be increased by the expense which would have to be incurred in the works necessary for that purpose. With regard to the deficiency of the depths of the rivers,—to make them capable of navigation by the larger class of vessels, proposed by Colonel Cotton, he believed to be wholly impracticable, and if any one—scientific or unscientific—looked into the question of making a large ship canal, he would find that it would be a work of millions of money, and would be a more expensive enterprise than any railway. The moment they came to the question of depth, the expenses would increase as the square of the depth, and, beyond a certain size, in a ratio much greater in proportion to the dimensions. They had an instance of a large canal—the Caledonian—which was constructed under favourable circumstances: it was not more than 15 feet deep, 60½ miles long, of which 37 miles were natural lakes, but it cost more than 1,100,000*l.* of money, and yet he believed the returns did not pay the expenses of the staff required to work it, whilst on the other hand no railway had been so unproductive. But, long ago, a canal mania arose, and he believed some 70,000,000*l.* were expended on those projects, the average returns from which, he believed, had been most unsatisfactory. Now, with regard to the 5,000,000 of tons of traffic, he (Mr. Ayrton) did not for a moment believe that that amount would be carried from any one place to any other place, over the same point, on any main line of railway. There were 2,500,000 tons now carried annually on the Ganges, but it would be found that about one-twentieth of that traffic came from Mirzapore to Calcutta.

Colonel Cotton—2,000,000 of tons come from one point, that is what I say.

Mr. Ayrton—They must not imagine that it came from Mirzapore, or from any single place. Some of the most fertile districts of Bengal were to the north and east of Calcutta. The 2,500,000 tons were made up of goods brought to Calcutta by water from all those districts, as well as from all the intermediate places between Mirzapore and the Hooghly. Much of the traffic on the Indian railways would be just the same as on the London and North-Western railway, between different places on the line and not along its entire length, and though it would, no doubt, be ample to make the railways remunerative, it would not approach the extravagant quantity of 2,500,000 tons on any part of the line. People spoke of the Ganges as if it were like the Thames, capable of being navigated from the wherry to vessels of the largest tonnage. It was a most extraordinary river. Land was formed and cut away with a rapidity that was astonishing. A man owning a fine estate on one side of the river, might after a flood of the river find it had vanished, and that a new estate was formed on the other side of the river. How were they to deal with such a river? It was impossible to convert it into a navigable canal deeper than it was formed by nature. If they were to excavate the bed, they would find it filled up again by a day's flood. It was said by Colonel Cotton, railways could not be used for a large goods traffic, but it was to be borne in mind, that the peculiarity and the speciality of English railways, in which they differed even from continental lines, was this—they were obliged to run numerous express and fast trains, at all hours, for passengers only. These obstructed their regular employment for goods traffic to a tenth of the extent of which they were capable of being used, if all the trains for passengers as well as goods went at an uniform speed, even if that speed were 20 miles an hour. But, in India there would not be the same demand for passenger trains, and if there were it would only prove the propriety of having constructed the railways, and that canal boats would have been most unsuitable. He wished to call attention to another fact—the circuitous course of canals, unless they were made wholly regardless of expense. A little way out of London they found the New River, or any of the canals, winding about, whilst the direct distance between any two places through which they passed was only about half their length. He would like to know whether Colonel Cotton's rates were for conveyance per mile along the canals, or whether he had reduced them to the direct distances, or whether in his statement of the rates on the Ganges and other Indian rivers, he had computed the cost by the river's length or by direct distance, for with regard to the Ganges, the distance from Mirzapore to Calcutta by it was about 800 miles; the direct distance being only about 400 miles. It appeared to him, also, that Colonel Cotton had made his estimate of the cost of transit by canals exclusive of the tolls, which went to pay for the construction of the canal itself, and the comparison he had drawn from the tables prepared was, therefore, only of limited application. They did not embrace many charges which constituted the commercial cost of transit, and which were all included in the rates charged by the railways. To omit the tolls on canals was to disregard the entire cost of constructing them. He would allude to one more point only, as the time was limited. He would ask Colonel Cotton whether, in stating his broad propositions, he had considered the quality of the soil in particular parts of India. The soil over a great part of the country was not retentive of water, and anything in the shape of a canal would have to be made retentive of water by artificial means, throughout its whole course, and, therefore, could not be compared with the canals cut in many parts of the delta, where the water would be retained in any channel which might be cut for it; and he would also like to know on what assumption the gallant gentleman had proceeded in laying down the data for the cost of irrigation; whether he had estimated that the water might have to be drawn from any and what depth, or whether he calculated upon an interminable supply of running water. In many parts it might be 5 feet or 50 feet below the surface, and then what would be the cost of irrigation.

Colonel COTTON said it was again so late before an opportunity was given to him of answering the objections that had been made, that he must content himself with selecting a few of them on which to make his remarks. He would begin with Mr. Ayrton's arguments against water being a remedy for famine. That gentleman said:—

> "Canals, as applied to irrigation, would be no remedy for famine. The rice, wheat, and other varieties of grain, would not be raised by artificial irrigation when they could be grown by the showers of Heaven without cost. The great staple food of man and cattle in India would be produced by those crops which were given by the bounty of Providence from the sowing of the seed, and by the action of the periodical rains upon a naturally fertile soil. It was to be remembered that produce did not fail till all the mischief was done, which no artificial irrigation would remedy. When the husbandman sowed the seed, he was under the expectation of the ordinary periodical showers; he waited for them from day to day, and if they failed then famine had arisen, and no system of irrigation would ever prevent the calamity." He then adds—"He saw several gentlemen shake their heads."

No wonder. What would any one of ten thousand black men say to such white wisdom? Every chain in this grand argument implied the most complete ignorance of the facts of irrigation. It was one of the innumerable queer things that this gentleman had spoken. It would take him a long time to show the absurdity of everything he had said when he touched upon engineering matters. He might have just as well delivered a lecture on watch-making. He would just mention some things showing the nature of his career in India, because it seemed necessary that the meeting should know that he had real grounds for speaking without presumption on these matters. He did not get any knowledge of irrigation and Indian rivers in a lawyer's office in Bombay. After a short employment in the field, soon after his arrival in India, he was called to the civil duties of an engineer. The first work he was called to was the examination of the pass between Ceylon and the main; this brought Court questions under his notice. He was then appointed to the charge of irrigation works and communications in various districts of the Madras Presidency, in the course of which every kind of country was brought under his notice, hill country, undulating tracts and deltas, forest, jungle, and open plains, with soil and rock of every description. It was in the course of these occupations placed in charge of the delta of the Cauvery, and employed in throwing two weirs across that river, which was 1100 furlongs broad at the site of the upper one, and in the planning and executing innumerable works connected with both communication and irrigation, bridges sluices, locks, tunnels, &c., as well as in controverting and regulating these to the rivers. Latterly he was employed in the Delta of the Godavery, where a weir had been constructed across the sandy bed of the river, at a point at which it was just four miles broad, including low islands, which were under water when the river was full. From this river, channels to contain 1¼ millions of cubic yards per hour, were led off; 1,200,000 acres would be irrigated, and full 1000 miles of connected water communication would be completed. He must be excused mentioning these things, because Mr. Ayrton endeavoured to give what was a totally incorrect representation of the whole matter, by commencing his speech with talking of Colonel Cotton's *theory*, as if he came here with some wild speculations on what he thought would be the effects of some untried plans. He had been thirty years coming to his conclusions, and these thirty years had not been passed in cantonments, but in tents, in actual contact with the matters of which he spoke. He had always been looking for, and had indeed been compelled to see, the actual results of such operations. He had brought before the Society, in his paper, real facts, and fair arguments based upon those facts. Now, to endeavour to make it appear as if he was merely bringing forward a theory, was certainly not calculated to help us in finding the truth, as Mr. Ayrton said he supposed the object was to investigate truth. He was sure we should never get at the truth in this way. Now, to return to the subject of the effect of irrigation in preventing famine. We had heard what Mr. Ayrton's ideas of irrigation were. But what was its result? One plan was this—we went to a river, like the Godavery, for instance, which never failed, and which conveyed, when full, water enough in three days to water the whole Delta all the year round; we threw a weir across it to raise the water, and then cut channels so as to lead the water to the surface of the land. These channels were thus kept flowing all the year round, through both the monsoon and the dry season. The cultivators opened a sluice, flooded their lands, and commenced their cultivation, with as great a certainty of a supply of water as was possible, instead of being dependent upon the local rivers, which were always very irregular, and sometimes failed entirely. Another way was to form large reservoirs (tanks) filled by damming up some large stream, or by cutting a channel from some rivers. Some of these tanks contained water enough for one year, some for two whole years. When the tank was a quarter or half filled the cultivator sat about his operations with confidence. Now compare these actual facts of irrigation with Mr. Ayrton's ideal sketch of it. And this gentleman told us, "he knew something of irrigation." He thought nobody present could find much difficulty in apprehending that the proposition, "Irrigation cannot prevent famine," was rather more *theoretical* than his views. Then Mr. Ayrton spoke of a theory for the whole of India, and that it must be wrong. Did he apply any theory to the whole of India? What were his words—"What has been done and is now doing in Rajahmundry, *or corresponding works, according to the nature of the country*, should be at this moment going on in every district in India." And again, "All the districts certainly could not be improved in nearly *the same way* as Rajahmundry, because it is a delta, and has peculiar advantages both for irrigation and water communication, but they ought all to be improved *on the same principle*, that is, every advantage should be taken of the peculiar natural facilities of each district to supply it as quickly as possible with these two grand requisites—irrigation and cheap transit." What had this to do with a general theory for all India? Let us now consider what he said about the Damooda. He gave a dreadful description of the navigation of the river, and no doubt it was about the worst of the navigable rivers of India; but hitherto it had conveyed all the coal from Burdwan to Calcutta. But now how did matters stand? As a remedy for this all the skill and experience that could be procured in England was brought to bear upon a land communication; and 20,000*l.* per mile was spent upon it.

Mr. Crawford—10,000*l.* a mile.

Col. Cotton believed that a much larger sum had been spent; and now we had all that science, experience, and Western energy, and enormous sums of money, and backed up by steam power could do, to oppose this wretched river being navigable, on which not one European thought nor one shilling had been expended, and worked by human labour. What an unequal contest; of course the question of the issue of it answered itself; nobody could dream that a ton of coals could ever again be put into a boat. Well, in the last mail it was said that at last, after several months' discussion, the coal company had come to an agreement with the railway company to give them the transport of their coal. But by a report of the matter from a Bengal newspaper about three months ago, the negotiations at that period, after having been continued a long time, failed, as the railway company could not undertake to convey at a rate that would be altogether cheaper than the river transit.

Mr. Crawford stated that an agreement had been made to carry them at 1d. per ton per mile.

Col. Cotton—The Ganges transit cost under three-eighths of a penny a ton, and allowing for the acknowledged inferiority of the Damooda, there could not possibly be much advantage to the coal company to have their coals carried at 1d. per mile. Now he begged to call attention to this case, because it was admirably to the point. It was all but a balance between the railway costing 10,000*l.* a mile or more, and worked by steam, and an unimproved river worked by human power. Thus, from his knowledge of Indian rivers generally, and from what he had read of the Damooda, he had not a doubt that five-eighths of the evils of the navigation mentioned by Mr. Ayrton could be removed at an expense of 100*l.* or 200*l.* a mile; in which case the railway would not have had a chance with the river in the conveyance of heavy traffic. He had no doubt whatever that a fiftieth or a hundredth part of what the railway cost would reduce the cost of the river transit to a farthing a mile, including risk and all items. But thus it was; we spent unlimited sums on land and enabled ourselves to use steam on it, while we left the water totally unimproved, and then said, "See how superior land transit is to water;" indeed, in this case, it was after all difficult to say which was superior for heavy traffic, this worst of unimproved rivers or the railway. Mr. Ayrton next spoke about the enormous cost of ship-canals, and said that millions were spent upon them. Thus, again, did he (Colonel Cotton) say one word about ship-canals? What were we to think of a cause which compelled men continually to put words into his mouth which he never spoke. If they could answer what he did say, they certainly never would take the trouble to answer things he did not say. But what had the fact of a million being spent on the Caledonian Canal to do with steam-boat canals for India? What was the actual cost of canals in India? Take the case of the Ganges canal; its length, with its two branches, was 850 miles; its dimensions at the head were 60 yards broad, with ten feet deep of water. It diminished gradually to the other end, where it might be perhaps 10 yards broad and 6 feet deep. Now this immense canal, which was nearly completed, would have cost about 2 millions sterling, or 2400*l.* a mile. This was a specimen of the cost of canals in India. With respect to the cost of canals in England, he had a conversation with the proprietor of one of them, which was remarkably to our present purpose. It was the Oxford canal. He said, "you have a fair contest with a parallel railway, what are the results?" He replied, "Oh! they have ruined us." "Well," I said, "but what is the actual state between you." "What is your dividend?" "12 per cent." "This is a curious way of being ruined." "Oh! we used to get 32 per cent." So the ruined canal was, at this moment, yielding 12 per cent., and the victorious and flourishing railway about 4 per cent. In investigating this question, in which such large words had commonly come into use about railways, we must take care to ascertain what meanings now attach to the words we use. The cost of this canal was 2,500*l.* a mile, and one part of it had since been improved; it was cut very straight, as straight as many railways, made half as wide again as it was at first, and in fact required little more to be done to it to make it a steam-boat canal, and this part of it, both in original cost and improvements together, cost 6,500*l.* a mile, one-sixth of the cost of a railway. He must now advert to what was said about the power of railways to convey the great traffic of a country. It was said, that in England, the grand obstacle to it was "fast trains." Now, what was the one object for which everything else was being sacrified in these Indian railways; it was speed. What could have been said that would have more powerfully supported the main points of his position, than this that was so brought forward. This was what he insisted upon, that if we would give up this idol "high speed," we could do any thing, and that for this comparatively insignificant object, we were sacrificing all the real interests of the country. And in answer it was said, that the ground obtacle to the railways carrying the great traffic of the country, was the high speed of some trains. Now only give up the high-speed trains in India, in order to enable you to carry the great traffic, and you give up your whole position. If high speed was given up, and the people were satisfied with a moderate one, such as from 3 to 6 miles for goods, and 8 or 10 for passengers, and improved rivers, and canals, and light railways, would more than answer all our purposes, for they would give us more speed than this at very low rates. There was not time to reply to a tenth part of the uttered or implied mistakes in the different speeches to-night, but he thought this *exposé* would afford a tolerably correct estimate of the shadowy nature of these objections generally. And no time at all was left him to say what he ought to have been allowed time to say on the real points of the question. He believed there were few gentlemen in the room who had a stronger opinion than he had of the advantages of high-speed railways. But our question was this—Under the circumstances of India which would be most beneficial, a few miles of high-speed railway, that would convey goods at a penny a mile, and carry passengers at thirty miles an hour, or ten or twenty times the length of some other kind of communication that could convey goods and passengers at 1-4th or 1-10th of the cost by rail, but with a moderate speed—suppose 50 or 100 miles a day for goods, and from 200 to 300 for passengers? This was the question which had been so studiously kept out of view by the different speakers. And no wonder, for it would not bear an hour's discussion. Was it wise to throw away all the natural facilities and advantages which the country afforded, and to leave the great body of the country without either cheap transit or irrigation for the sake of two or three lines of railway, which, when done, could neither carry the quantity nor at the low cost which the country imperatively demanded. The ten years, and the thirty or forty millions that it was proposed to spend on these works, would go far to secure every part of India from famine, would provide food for the whole community by means of irrigation, with the labour of a comparatively small portion of the population, and would bring cheap transit to within fifty miles of every point, together with a very fair speed, quite sufficient for all present purposes. And when these great essential ends were obtained we might proceed to provide ourselves with rapid passenger transit.

The Chairman said he must claim attention to the subject of one art, the art of the collection and distribution of water as means of giving fertility to a large proportion of the soil of India, and to the mode in which it had hitherto been conducted, and was proposed to be conducted. One speaker (Mr. Ayrton), whilst deprecating generalities, in respect to the whole of that continent, had yet stated one general condition under which it was placed, of sudden and immense floods, of torrent-filled rivers, and of prolonged droughts, which certainly demanded works of extensive generality and magnitude for the collection and storage of these sudden falls, and for their regulated distribution. Such works had been commenced by the Company, but in important respects on erroneous principles. It appeared that the water leading was by open cuttings, in the branches as well as the mains, and that the ultimate distribution was mostly by the method of submersion. Where the mains were not stagnant, and where they could be made to serve the purposes of traffic as well as of water distribution, the method of conveyance by open cuttings had, no doubt, compensating advantages; but in Peru, where the Spaniards raised enormous cereal crops by irrigation, it was a saying, that to lead water in open cuttings, was to lead it into the air; and it must be so, to a great extent, in India. This appeared to have been formerly well understood. In Colonel Chesney's work might be found the native remains of ancient water-leading, by covered channels under the present arid and desert seats of former populations and civilisation. The method of ultimate distribution by the water meadow, old though it might be, was open to the fatal objection that it created marsh surfaces, and engendered marsh miasma. The Chairman, in his sanitary researches in England, had found, and it was abundantly proved, that the water meadows generated the rot in sheep and the ague in men. His friend, Captain Baird Smith, in his able report on the Italian irrigations, had stated the fact, that from experience of the injurious effects of such irrigations, the formation of such works was in several states prohibited within six miles of towns; but he did not appear to have given to that fact its due and decisive weight. If such were the effects in European climates, it might be expected that they would be aggravated in the East by a more rapid decomposition under a more powerful sun; and so they were. Medical reports which he had seen, shewed, particularly in the province of Agra, peculiar manifestations of the malarious influence in the enlargement of the spleen. The medical men reported that they could tell by the extent of enlargement of the spleen, the extent to which the population had been exposed to the malarious influence. Now he, the chairman, had a large faith that unwholesome processes were not intended, and were not the best for the most economical or the most productive results. One effect of them was almost to necessitate with the inferior labour, a depressed, inferior, and expensive population. In some consultations on drainage works for the productive and sanitary improvement of Guiana, he was not surprised to find the slave labour in reality dear, as well as inferior labour, obstructive of improvement. He had been assured by a large planter, that he could afford to give as much as 3s. per diem for labour as good as common day labour in England. Then, why not import it? The answer was, that it had been tried, but that the free labourers could not stand the climate, and would have recourse to rum, which destroyed their value as labourers. What was called "the climate" was, in the particular instance, the miasma from the stagnant ditches used to drain the land, and which so closely intersected it, that the plough which might there have been otherwise used, could not run. In England, he had promoted the use of covered but permeable tile drains in substitution of the open ditch drains, which commonly surrounded our towns as well as lands, and they were now proved to be the most economical. The late Dr. Shier agreed that in the particular instance they would have removed the barrier to the introduction of superior labour, as well as the obstructions to the working of the plough. It appeared that, in consequence of the irresistible evidence in India of the effect of the miasma from the irrigation by submersion, it had been provided that they should not be carried on within such distances as three miles from a town. If, however, six miles distance were required for the protection of the population of Italian towns, three miles was certainly too short a distance in India. He had evidence even in England that marsh effluvium had been perceptible for fifteen miles. After a continued prevalence of wind from over the marshes and open ditch drains in Essex and Kent, at Plumstead, comparatively weak as was the power of decomposition here, scattered cases of marsh fever—known as such to medical officers conversant with the marsh diseases—and ague, were found to occur amongst the population to the very extremity of the metropolis. In some of the reports of the Company's officers, it was stated as conclusive and satisfactory, that from the provision made, "only a few" cases of enlarged spleen occurred amongst the adjacent population. To those who understood the subject, however, "the few" developed cases, which usually on examination turned out to be not a few, denoted the prevalence of wider deleterious influences. But this supposed protection wholly disregared those who were to labour in the artificially created marshy surfaces; it was in ignorance of that to which he must repeatedly call attention as a practical economical principle—that inferior processes, processes which were physically injurious and depressing, made inferior labourers and inferior populations. He was happy in being able to convey confident assurances that these unsanitary consequences were avoidable, and, moreover, were avoidable with a profit. From having been compelled to struggle with the difficulties of dealing with the refuse of towns, he had been led to propose, in substitution of the practice of applying liquid manure by the method of submersion, the principle of pipe distribution or the application of liquified manure by pipes and hose and jet. This was now in course of increasing application in farms, and its sanitary success would be found to be everywhere demonstrated. As with applications by the horticulturist, or by the gardeners' water-pot, no more was given at one time than the soil could at once absorb. Plants whose natural habit was not submersion in liquid, were not subjected to it. There was no stagnant water and no decomposition. Even where liquified manure was applied, there was an immediate chemical combination with the soil, which it was proved retained it permanently, and there was no loss from decomposition, and no atmospheric pollutions from that cause. There was also a large economy of water. But what perhaps was of the most immediate importance, there was a large economy of original outlay, as well as in working expenses. Captain Baird Smith, in his report on the Italian irrigations, had shown that as much capital as 40*l.* per acre had been expended in the construction of the water meadows and the connected works. The average cost of the Wiltshire water-meadows was about 16*l.* per acre. The Chairman held in his hand a tabular view of the comparative outlay and the working expenses. From this table (*see next page*) it would be perceived, that the total cost of the works and apparatus of all the prominent examples examined of irrigation, by bed works and gutters, including the instance of catch water meadows, had been 31*l.* 14s. 7d. per acre, and that the total annual charges and working expenses were 3*l.* 7s. 1d. per acre; whilst the cost of the new works and apparatus on the average of all the examples of distribution by underground pipes had been 2*l.* 7s. 1d. per acre, and the annual charges and working expenses 8s. 11½d. per annum per acre. The cheapest instance found of the method of distribution by open gutters, the Pusey catch-water meadows, was 14s. 3d. per acre, whilst the total annual expenses of the cheapest method of distribution by closed channels and underground pipes, and by jet and hose, was 7s. 1½d. per acre. The detailed particulars of works from which every competent officer might judge for himself were to be found in the official minutes published on the subject, and one additional advantage would be seen in this, that the works did not confine the cultivation to one method, but were equally applicable to arable and to arboretal cultivations. From what had been stated of the cheap rate at which water was raised in India by simple means, there could be little doubt that the experience here as to economy of construction and working were applicable, *mutatis mutandis*, to India. It should be our mission to introduce into that country the most advanced improvements of modern civilisation, and our dominion should be based on the benefits rendered by it to the population. Care should be taken that in mere routine, and from poverty of resource in adaptation, we did not introduce European defects. This was of primary importance in relation to those works on which the productive powers of the country must mainly depend, namely, those for the adjustment of the supplies of water. At the same time the company's service, military as well as civil, furnished some of the most brilliant examples of fertility of resource and administrative ability in the empire. It would have enlarged the sphere of their discussion, and presented an example worthy of high regard, as it appeared only imperfectly known in India, and almost totally unknown in this country, if, from the papers officially printed by the company, he might have presented to them in detail the example of the conquest, the reclamation, and the civilisation of the Mairwara, of which the foundation had been laid by Colonel Hall, of the company's service, but the brilliant superstructure had been worked out by Lieut. Col. C. J. Dixon, of the Bengal Artillery. It was the case of a wide range of hilly district, badly cultivated, infested by wild beasts in jungles, and occupied by a robber population, whom it became necessary to subdue, for the protection of the inhabitants of the surrounding districts. Under ordinary routine, it would have been merely garrisoned at a great expense, but Colonel Dixon perceived that the failure of the crops from the irregular supplies of water, at times necessitated predatory habits, to which the long intervals of labour from a rude and bad cultivation gave them leisure. To meet this condition Colonel Dixon projected works for the collection, storage, and distribution of water. He obtained government advances of money, and occupied the robber population in their construction. Subsidiary works were designed, money advanced, and the same population was engaged in the reclamation of jungles and in that steady and highly productive cultivation, which the adjusted water supply and distribution afforded the means. The time of the population was so well occupied, that they had no leisure nor inducement to think of depredation. He succeeded in doing there what our administrators had not succeeded in doing here, in making absolutely condemned criminals prefer honest and productive industry. For cultivation and the conveyance of produce, roads had to be made, villages to be constructed; for the supply of the villages a town had to be created, and for the sale of the produce, markets and fairs to be instituted. The Government advances of capital were repaid with interest. Instead of laying black mail on the surrounding population, instead of occasioning the expenditure of a revenue, in maintaining the repressive action of troops, the district now furnished good subjects and good troops, and a good revenue for the maintenance of the local as well as the general government, from a thriving and increasing population. All this had been done in a very few years, and the instance might be cited in proof of the possibility, by similar administrative appliances, of altering completely the condition of that empire within the span of one generation. The following is the table of the comparative cost and working of the two descriptions of works, as applied to the distribution of liquified manures, and referred to by the chairman:—

Name of Place.	No. of English Acres.	Mode of Application.	Total cost of works & apparatus per acre.			Annual interest, &c., at 7½ per cent. per acre.			Annual working expenses per acre.			Total annual charges per English acre.			Observations.
			£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	
NOTTINGHAMSHIRE: Duke of Portland's Clipstone Meadows	300	Catch-meadow, gravitation, and open gutters..............	120	0	0	9	0	0	0	10	0	9	10	0	Previously worth from 3s. to 5s. per acre per annum, produce now upwards of 12*l.*
EDINBURGH: Craigentinny Meadows: High Level	63	Steam engine, pumps, and open gutters and panes	31	14	11	2	7	7	1	17	4	4	4	11	Average rental, upwards of 16*l.* per English acre.
Sea Meadows	38	Gravitation, open gutters, and panes	18	8	5	1	7	7½	0	10	5½	1	18	1	Worthless 25 years ago, now worth 520*l.* per English acre.
Old Meadows	228	Gravitation, open gutters, and panes	11	16	10	0	17	9	0	10	5½	1	8	2½	Maximum rental, 25*l.* per English acre.
WILTSHIRE: Wiley Meadows	150	Bed-work of ridge and furrow, gravitation & open gutters	20	0	0	1	10	0	0	7	0	1	17	0	Four heavy crops of grass per annum.
DEVONSHIRE: Duke of Bedford's Tavistock Meadows...	90	Bed-work, and catch-meadow, gravitation & open gutters	13	2	10	0	19	8½	0	15	0	1	14	8½	Land more than quadrupled in value after only five years irrigation.
BERKSHIRE: Pusey Meadows	100	Catch-meadow, gravitation & open gutters	4	9	0	0	6	8	0	7	7	0	14	3	Land not previously worth more than 5s. per acre, now yield 6 heavy crops of grass per ann.
STAFFORDSHIRE: Duke of Sutherland's farm near Trentham	83	Steam engine, pumps, underground iron pipes, gutta percha hose, and jet pipe ...	6	5	5	0	9	5	0	4	4¾	0	13	9¾	Tanks constructed sufficient for 300 acres.
GLASGOW: Mr. Harvey's farm......	508	Steam engine, pumps, underground iron main pipes, and iron distributing pipes	2	17	1	0	4	3½	0	9	5½	0	13	9	10 feet thick of grass cut from an acre in six months.
GLAMORGANSHIRE: Porth Kerry Farm......	50	Gravitation, iron pipes, and gutta percha hose	6	0	0	0	9	0	0	4	0	0	13	0	Tanks constructed sufficient for 300 acres. Upwards of 9 feet of grass grown.
AYRSHIRE: Mr. Kennedy's Myer Mill farm	508	Steam engine, pumps, underground iron mains, gutta percha hose, and jet pipe ...	3	2	6	0	4	8¼	0	6	4¾	0	11	1	70 tons of grass cut from an acre in six months.
Mr. Telfer's Canning Park farm............	50	Ditto	4	4	0	0	6	3½	0	4	4¾	0	10	8½	14¼ feet thick of grass cut in 7 months.
LANCASHIRE: Mr. R. Neilson's Halewood farm............	120	Ditto	4	6	11	0	6	6¼	0	3	3½	0	9	9¾	One dressing of liquid found equal to 25 to 30 tons of solid farm-yard manure per acre.
CHESHIRE: Mr. Harrold Littledale's Liscard farm	150	Ditto	4	9	7	0	6	8½	0	2	4½	0	9	1½	A fourth crop of grass, equal to 10 tons per acre.
Marquis of Ailsa, Leg or Dunduff farm ...	50	Gravitation, underground iron mains, gutta percha hose, and jet pipe	3	16	5	0	5	8¾	0	1	4¾	0	7	0¾	12 stacks per annum previously; 80 stacks last year.

The following is the letter received from Mr. Bourne, mentioned at page 431.

Greenock, April 5th, 1855.

Sir,—It would have given me much pleasure to have been present at the Society of Arts next Monday, on the occasion of the discussion arising out of Colonel Cotton's paper "On Public Works for India," but as I am unable to promise myself that gratification, I willingly accede to your suggestion that I should send you a few observations, such as I would have ventured to offer had I been able to attend.

With many of the topics discussed by Colonel Cotton I do not profess to be familiar, but having now for a number of years given constant attention to the question of internal communication in India, and having by personal investigations in India, and by collecting from all available sources the best information that I could obtain, endeavoured to arrive at practical and unbiassed conclusions upon the subject, I think myself warranted in stating my belief that my opinions will not be found to be incorrect in many important particulars.

The great want in India is the want of internal communications. All parties are agreed upon that. This want may be relieved by the construction of roads, and railways, and canals, and also by improving the navigation of the rivers already subsisting in that country. Now, India is so vast a country, that to cast over it such a network of roads, or railways, or canals, as would effectually or largely subserve the purposes of internal communication, would cost a larger sum of money than could readily be collected for that purpose, and if we rely wholly on these instruments of amelioration, we cannot expect to make any very large progress in improving the internal communication of the country for a number of years. No doubt roads, railways, and canals, should be made, so far as we have the means of making them, in all those situations in which improved communications are very desirable, and in which there is no cheaper expedient available for satisfying the want; and the selection of the particular kind of road which should be adopted must depend upon local circumstances, as, indeed, will be obvious to every one. The rivers, which in other great tracts of country are the main arteries of internal communication, are in India so shallow and so full of sandbanks, that to navigate them by steam vessels of the kind commonly employed in other countries, is impossible, or, at least, possible only to a very limited extent, while to deepen those great and shifting rivers, so as to render them suitable for navigation by steam vessels of the ordinary form, would, as a general rule, be a far more costly operation than to construct contiguous lines of railway or canal. Although, however, we cannot expect to adapt the rivers of India to our familiar modes of navigation, it became obvious to me, from my investigations in India, that to construct vessels which should be of such a character as to be capable of navigating the shallow and shifting rivers of India, was a problem by no means beyond the power of engineering science to solve. On the contrary, it appeared to me that the construction of such vessels would be by no means a difficult achievement. If such rivers had existed in England, I felt persuaded that they would have been effectually navigated by steam long ago, and the only reason to which I could attribute the circumstance of their not being so navigated, was that few mechanical engineers had ever visited India, or were acquainted with the peculiarities of the rivers of that country, or were cognizant of the vast extent of country which any effectual expedient for navigating them would open up. I calculated that by establishing, upon the rivers of India, steam vessels of light draft, and of otherwise suitable construction, to overcome the difficulties of the navigation, about *ten thousand miles* of river would be opened to navigation by steam, without doing anything to improve the rivers at all. No doubt it would be found expedient to remove impediments out of the beds of some of the rivers at certain points, but this improvement, though desirable, was not necessary, and by the simple expedient I have mentioned, about ten thousand miles of great steam highway would be obtained, without any other expense than the construction of the steamers necessary to run upon it. Such an improvement as this, if really feasible and practical, must be admitted to be of much value, but the East India Company, to whom I applied six or seven years ago upon the subject, denied its feasibility, and refused to make the experiment. I, thereupon, in conjunction with some friends, offered to make the experiment at my own expense, requiring only, in the event of the success of the experiment being completely satisfactory to the East India Company, that a moderate recompense should be made for it, but after several references to India, and an appalling amount of reports and correspondence, the offer was declined, and the great advantage of the achievement, even if successful, was, at the same time, denied. I found that the main opponents of my proposal were the persons interested in the existing railways, which led me to believe that they, at least, believed it would be so successful as to render superfluous some of the expensive schemes of railway communication then proposed to be undertaken. My view, however, is, that railways are necessary too, and that there is abundant scope in India for their advantageous operation. But I think that, for the purposes of commercial transit at least, the railway should only begin where the waterway terminates, and that it is a waste of power to make either railways or canals by the side of a river which is susceptible of navigation by steam, so long as there are vast tracts of country where there are no rivers, or where the rivers are too small, shallow, or steep, to be navigable, awaiting the benefits of improved modes of transport. Of course there are many rivers in India, as in every other country, which cannot be navigated at all, even with any conceivable species of vessel; but there are also great numbers of rivers ramifying throughout the country, which can be so navigated as to convey articles of every kind at a cheap rate of freight, and at a considerable rate of speed. All the rivers of India are subject to periodical inundations, but this does not prevent them from being navigable. Some are merely large torrents, which are only susceptible of navigation during the rains, and in summer are dry, or form only a succession of long pools. Of course, no one proposes to undertake the regular navigation of such rivers as these, but, after all these impossible or doubtful rivers have been set aside, there still remains about ten thousand miles of rivers in India which have always water in them, and which are susceptible of navigation, by suitable vessels, at all seasons.

It would swell this letter to inconvenient dimensions, if I were to enter into any detailed description of the particular rivers of India which are navigable throughout the year, of the distance from the sea to which they are navigable, or of the particular species of vessel by which their navigation may be accomplished. I may mention, however, that the Ganges and Jumna, and some of their chief tributaries, are navigable to within a comparatively short distance of the point from whence they issue from the Himalaya and the Indus—and other great rivers of the Punjaub are navigable up nearly to a chain of mountains called the Salt Range, situated not far distant from the range of the Himalaya. The Mahanuddy, Godavery, and some other rivers of Southern India, are navigable also through a considerable part of their course. The rivers flowing from the Himalaya to the sea, being fed by melting snows, have much water in them in the height of summer, and most of the great rivers of India take their rise in this great mountain range.

It will be seen from this general explanation of my views respecting the internal communications of India, that they are, as I believe, identical with those so effectively propounded by Colonel Cotton, and, although there may be differences of opinion upon small points among those discussing the accuracy of his views, I believe that his main propositions cannot be controverted. Whatever we may think of the respective merits of railway and river transport, I think we must come to the conclusion that as we have not got the railways to any considerable extent, but have got the rivers which we can largely use without any expense but that of the locomotive power, we ought in the mean time to use the rivers as far as possible; and should the river communication be in time superseded by a railway, there is no loss involved in inconvertible works, but we have merely to shift the steam-vessels to some other river where no railway competition yet exists. It does not appear probable, however, that the existence of railways in India will supersede water conveyance, since it has not been found to do so in other countries. In 1846. when I drew up the traffic estimates of the East Indian Railway, I found that, unless it acquired a large proportion of the Ganges traffic, it could not be expected to be remunerative, and that it could not expect to acquire this traffic if the charge was more than 1d. per ton per mile. In the estimates made at the same time, by Mr. Chapman, for the Bombay Railway, and for which, at that period, no river competition was apprehended, the charge set down for goods was 2¾d. per ton per mile, and I presume the charge would be kept up to this amount, or up to such an amount as would suffice to compete with land carriage, unless a water conveyance were opened from Berar to the coast by the Godavery, which will afford the only assurance that can be got that cotton will continue to be conveyed to the coast at a cheap rate. If this cannot be done, then the supporters of the railway cannot be damaged by the experiment. If it can be done, as from their opposition to the project the railway advocates appear secretly to believe, then the public will be gainers by the increased cheapness of transport thus obtained.

From all I saw or could learn of the rivers of India, while engaged in engineering operations in that country, and from all the information I have been able to obtain, as to the expedients in successful use for navigating rapid and shallow rivers in other parts of the world, I have, I think, accumulated sufficient evidence to enable me to state with confidence that a large portion of the rivers of India may be navigated by steam in such a manner as greatly to accelerate and cheapen the internal communications of that country, and these benefits may be realised without delay, and at small expense. I believe that improved communication must be improvements calculated to increase production, else a market cannot be obtained for the additional articles produced; and to the same extent to which new outlets are afforded to Indian productions, will new inlets be afforded to British manufacture.

I am, Sir,
Truly yours,
J. BOURNE.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 9, 1855.

The Twenty-first Ordinary Meeting of the One Hundred and First Session, was held on Wednesday, the 9th inst., Joseph Glynn, Esq., F.R.S., in the Chair.

The following Candidates were balloted for and duly elected:—

Bell, Edward.
Cox, John.
Eardley, Eardley Gideon Culling.
Oliver, Joseph.
Paden, Stephen.
Ricardo, Samson, M.P.

The following Institutions have been taken into Union since the last announcement:—

390. King's Cliffe (near Wansford,) Reading Society.
391. Battersea branch of Belmont Mutual Improvement Society.
392. Belmont (Vauxhall) Mutual Improvement Society.

The paper read was

ON THE MANUFACTURE OF STEEL, AS CARRIED ON IN THIS AND OTHER COUNTRIES.

By Charles Sanderson.

The manufacture of steel is of great antiquity, coeval, if not anterior, to that of iron; it was known to the Chaldeans, the Hebrews, and the Greeks; the processes they are said to have used are detailed by Aristotle, Pliny, and Plutarch, but they are so obscure and contradictory that no reliance can be placed upon them. It appears most probable that steel was, in the first instance, produced accidentally, whilst attempting to obtain iron. This question is, however, more curious than useful; I therefore dismiss it, and turn to the subject before me. Steel is a carburet of iron, more or less freed from foreign matter; it can be produced by two processes, opposed to each other; the first, or earlier method, is by working pig iron, which on an average contains 4 per cent. of carbon, in a suitable furnace, until the carbon it contains is reduced to that quantity required for steel, which is 1 per cent. The second method is to heat wrought iron in bars (which contain little or no carbon), in contact with some carbonaceous matter, until it has absorbed that quantity of carbon which may be required for hard or soft steel purposes.

The various kinds of steel which are now manufactured in this and other countries, are:—

Natural or raw steel, which is manufactured from crude iron as obtained from the blast furnace;

Cemented or converted steel, which is produced by the carbonisation of wrought iron;

Cast steel, which is obtained by the fusion of either natural or cemented steel, but principally from the latter.

In the manufacture of steel, the quality of the iron from which it is made is of the first importance; it is absolutely necessary that it should be free from earthy matter, silicates of the metal, sulphur, arsenic, &c. Any foreign matter contained in the iron is very injurious for steel purposes, but the silicates are, in my opinion, the most deleterious, since they produce a red short quality, caused by their mechanical mixture with the carbonised molecules of the steel, thus destroying the malleability of the mass. The mines of Danemora have for many centuries enjoyed the highest reputation for producing iron of the finest description for steel, and this alone should be used for producing the very best cast steel. The high reputation and scarcity of this iron have combined in commanding for it a very high price. The marks Ⓛ. $\underset{L}{G}$. OO. are made wholly from the Danemora ores; the marks $\underset{F}{G}$. $\overset{♔}{W}$. $\overset{♔}{B}$. Grid, and some others, receive only a portion of these ores mixed with others in their manufacture. Sweden produces also a large quantity of iron suitable for steel, but of inferior quality to the above, and technically termed 2nd and 3rd marks. The ores from which the Swedish irons are produced are almost wholly black oxides, usually containing 50 to 60 per cent. of metal; they are very clean and pure, and might, if properly manufactured, produce finer iron than that generally obtained; their works are, in too many instances, badly constructed, and the manufacture itself is so far from being perfect that there is a great unnecessary waste in the manufacture of the pig-iron into bars, and also in the quantity of charcoal necessary to produce a ton of iron; nevertheless, these commoner irons are sold for steel purposes. Recently some of the Swedish works have introduced our English charcoal refineries, and our mode of working, by which a sounder iron is obtained, and one freer from adventitious matter. The price of Ⓛ is £36; $\underset{\mathrm{L}}{\mathrm{C}}$ £33; OO £32; $\underset{\mathrm{F}}{\mathrm{C}}$ and $\overset{\text{♔ ♔}}{\mathrm{W}}$ £32; $\overset{\text{♔}}{\mathrm{JB}}$ £30; Grid and Stembuck, £24 at the present high prices; the iron called 2nd mark varies in price, according to its intrinsic quality, from £25 to £18. The 3rd mark from the latter price to as low as £13 per ton. Russia sends also a large supply of iron for steel purposes, of which the marks Kђ and IOP3 form the mass, being from 6,000 to 7,000 tons annually. This iron is of good medium quality, and sells readily at from £17 to £19 per ton in ordinary times. It is manufactured in the Ural district of Russia, by the usual charcoal refinery process. A part appears, however, to have been puddled, using wood for fuel. In 1830 it was a question whether a puddling furnace could be so constructed as to admit of the use of wood. Berzelius was of opinion that it could not. During my residence in Styria and Carinthia, in 1832, I erected a puddling furnace at the works of Mr. Rosthorn, in Wolfsberg, in which wood was used as a fuel. I experienced no difficulty in working it, and it produced very good iron, with a large economy of fuel when compared with the charcoal-refinery process. In this furnace I puddled 30 cwt. of charcoal iron in 24 hours. During this time I consumed 180 cubic feet of wood, as usually measured in the forest, equal to about 1½ cord our measure. The blooms hammered very solid, and the waste was 10 per cent. The furnace was a small one, and the fire-room much larger than that used for coal. Since this trial, several works have used the process, both in Sweden and Austria, but it has not become general. By this plan an excellent steel iron can by produced. Steel iron may also be produced direct from the rich ores of this and other countries. For this process Mr. Clay obtained the first patent; it was tried in Liverpool, but was unsuccessful, first, because he could not sufficiently deoxidise the ore, and subsequently, in its manufacture into malleable iron he could not get rid of the earthy matter—this rendered his iron unfit for steel, as well as ordinary purposes. I obtained the next patent, in which I provided for a more ample deoxidation of the ore, and also for the separation of the earthy matter from the metallic—this iron made good steel. There exists a variety of causes why this process has not been worked, although perfect in itself; it is, however, now about to be adopted for the production of steel iron from the rich ores of England, which, if properly manufactured, will produce an excellent steel. Since this important branch of manufacture is becoming daily of greater importance, every step towards the production of fine steel iron in this country should be encouraged, inasmuch as it makes our own resources available for our wants.

In the manufacture of common steel, particularly that for railway springs, a very large quantity of steel iron is produced from English materials. Of this kind of iron not less than 15,000 tons are annually consumed in Sheffield for springs and common hardware. This iron is produced from the coke-made pig iron, by puddling, during which process substances are added which, although not always the same, yet produce nearly similar effects.

Oxide of manganese, salt, sulphuric acid, and clay, mixed together, formed the patented substance of Dr. Schafhaeutl, by the addition of which into the puddling furnace the metal becomes freed in a great measure from the earthy matter contained in the crude iron, and a purer and denser iron is produced. It is well known that the process of puddling and rolling was the invention of Mr. Cort, of Gosport; it was introduced in 1784, before which period the charcoal finery alone was used. This invention opened a new and extensive field for the industry of the nation; coal became the medium of the manufacture of wrought iron instead of charcoal; and the process has expanded the production of this kingdom from 17,000 tons in 1740, to 3,000,000 tons in 1854. The facility with which malleable iron can be produced with coal has caused the erection of magnificent and colossal ironworks, finding profitable occupation for a great number of men, and producing throughout the ramifications of its manufacture, and its subsequent uses, an amount of wealth almost incalculable. This is somewhat foreign to the subject, excepting that, by the use of this invention, the steel iron market is annually supplied with 15,000 tons; and to me it is a pleasure, as it is a pride, to bring forward to public notice the invention of a man which has produced such astonishing results in our works, our railways, and steam navigation.

At present we are largely indebted to Sweden for our supply of suitable iron for the manufacture of steel.

The following is a statement of our importation since 1845:—

	Tons.		Tons.
1845 . . .	18,607	1850 . . .	28,096
1846 . . .	30,840	1851 . . .	35,467
1847 . . .	28,264	1852 . . .	23,817
1848 . . .	20,438	1853 . . .	23,540
1849 . . .	26,605	1854 . . .	24,436

With very trifling exceptions the whole of this iron is used for steel. The above figures give an average importation for ten years of 26,011 tons, to which we must add the importation from Russia and the steel now made in England. I therefore estimate the weight of steel manufactured in England at 40,000 to 50,000 tons annually.

The fuel used in England for the manufacture of steel is entirely coal and coke.

Coal is used in the converting furnace for heating the cases which contain the bar-iron during its process of cementation. In a properly-constructed furnace one ton of good hard coal is consumed in the conversion of one ton of iron, thus representing a consumption of 40,000 to 50,000 tons per annum for this purpose.

Coke is used in the melting process—the consumption being on an average 65 cwt. per ton of ingots. Although all iron is converted, and we can thus obtain the consumption of fuel, yet we have no means of exactly ascertaining the weight of cast steel manufactured annually in England. I should estimate it at from 25,000 to 30,000 tons. This would give a consumption of 81,000 to 97,000 tons of coke; and assuming that the coal will produce 60 per cent. of coke, it will represent a consumption of 113,700 to 136,500 tons of coal.

In Germany, France, and Austria, with trifling exceptions, steel is produced in a furnace similar to the charcoal refinery; it is termed raw or natural steel, deriving its carbon from the metal from which it is produced. Charcoal is the fuel used; the quantity is very variable, depending in a great measure upon the dexterity of the workman; we may, as a general average, estimate the consumption at 240 bushels per ton of raw steel produced.

Having laid before you an estimate of the raw materials used in the manufacture of steel, I shall now proceed to explain the processes which are used in various countries. The kinds of steel which are manufactured are:—Natural steel, called raw steel or German steel; Paal steel, produced in Styria, by a peculiar method; cemented or converted steel; cast steel, obtained by melting cemented steel; puddled steel, obtained by puddling pig iron in a peculiar way.

Natural or German steel, is so called because it is produced direct from pig iron, the result of the fusion of the spathose iron ores alone, or in a small degree mixed with the brown oxide; these ores produce a highly crystalline metal, called *spiegle eisen, i.e.*, looking-glass iron, on account of the very large crystals the metal presents. This crude iron contains about 4 per cent of carbon, and

4 to 5 per cent. of manganese. Karsten, Hassenfratz, Marcher, and Reamur, all advocate the use of grey pig iron for the production of steel; indeed they state distinctly, that first quality steel *cannot* be produced without it; that the object is to clear away all foreign matter by working it in the furnace, to retain the carbon, and to combine it with the iron. This theory I hold to be incorrect, although supported by such high authorities; grey iron contains the maximum quantity of carbon, and consequently remains for a longer time in a state of fluidity than iron containing less carbon; the metal is then mixed up, not only with the foreign matter it may itself contain, but also with that with which it may become mixed in the furnace in which it is worked. This prolonged working, which is necessary to bring highly carbonised iron into a malleable state, increases the tendency to produce silicates of iron, which entering into composition with the steel during its production, renders it red short. Again, by this lengthened process, the metal becomes very tender and open in its grain; the molecules of silicate of iron which are produced will not unite with the true metallic part, and also, whenever the molecular construction of iron or steel is destroyed by excessive heat, it becomes unmalleable; both these are the causes of red shortness, and also of the want of strength when cold. For these reasons I consider that grey pig iron is by no means the best for producing natural steel; and for the same reasons I should not recommend the highly-carbonised white iron, although it is now used both in Germany and in France. In Austria, however, they have improved upon the general continental process; their pig iron is often highly carbonised, but they tap the metal from the blast furnace into a round hole, and throwing a little water on the surface, they thus chill a small cake about ½ an inch; this is taken from the surface, and the same operation is performed until the whole is formed into cakes; these cakes are then piled edgewise in a furnace, are covered with charcoal, and heated for 48 hours; by this process the *carbon* is very much discharged. By using these cakes in the refining, the steel is sooner made, and is of better quality. In the opinions I have given to many German steel makers, and in the advice I have offered them, I have endeavoured to show that pig iron can only be freed from its impurities whilst in a fluid state. I take the advantage of the property of cast iron, and previous to melting it in the steel refinery, I submit it to a purification, by which process I seek to *reduce* the degree of carbonisation of the metal, and to separate and dissolve the earthy matter with which it may be combined; I then obtain a purer metal for the production of steel. The metal itself being to some extent decarbonised, is sooner brought into "nature," as it is termed; that is, it sooner becomes steel. The process being shorter, and the metal itself being purer, there is less chance or opportunity for the formation of deleterious compounds, which, becoming incorporated with the steel, seriously injure its quality. Of course, steel manufactured from crude iron, either purified or not, of any defined quality, will inherit such quality, be it good or bad. Art can in some degree remove these noxious qualities from the crude iron. Chemistry has lent its powerful assistance, yet nature will maintain her sway, and in all cases the good or bad qualities of the metal will be transmitted to the steel.

The furnaces in which raw or natural steel is manufactured are nearly the same, as far as regards their general construction, in all countries where such steel is produced; yet each country, or even district, has the fire in which the metal is worked differently constructed. We find, therefore, the German, the Styrian, the Carinthian and many other methods, all producing steel from pig iron, yet pursuing different modes of operation. These differences arise from the nature of the pig the country produces, and the peculiar habits of the workmen. These modified processes do not affect the theory of the manufacture, but they rather accommodate themselves to the peculiar character of the metal produced in the vicinity; in Siegen they use the white carbonised, manganesian metal, whilst in Austria a grey or mottled pig iron is used.

The furnace is built in the same form as a common charcoal refinery.

Fig. 1.

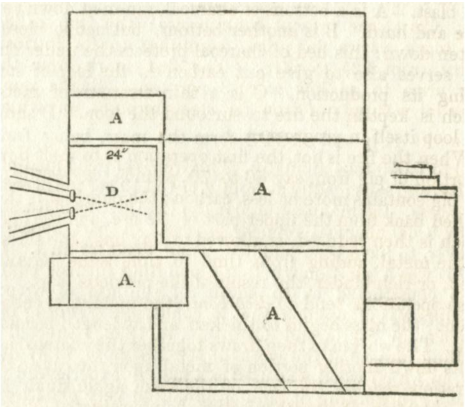

Fig. 2.

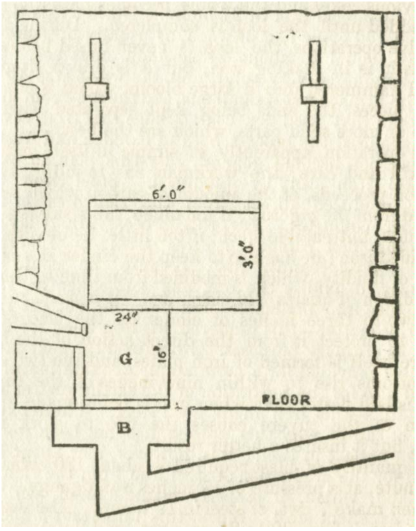

Fig. 3.

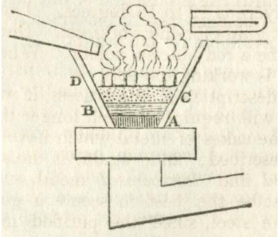

Fig. 1 shows a ground-plan of the furnace; Fig. 2 an elevation; and Fig. 3 the form of the fire itself and the position of the metal within it. The fire, D, is 24 inches long and 24 inches wide; A, A, A are metal plates, surrounding the furnace.

Fig. 2 shows the elevation, usually built of stone, and braced with iron bars. The fire, G, is 16 inches deep and 24 inches wide; before the tuyere, at B, a space is left under the fire, to allow the damp to escape, and thus keep the bottom dry and hot.

In Fig. 1 there are two tuyeres, but only one tuyere-iron, which receives both the blast nozzels, which are so laid and directed that the currents of air cross each other, as shown by the dotted lines; the blast is kept as regular as possible, so that the fire may be of one uniform heat, whatever intensity may be required.

Figure 3 shows the fire itself, with the metal, charcoal, and blast. A is a bottom of charcoal, rammed down very close and hard. B is another bottom, but not so closely beaten down; this bed of charcoal protects the under one, and serves also to give out carbon to the loop of steel during its production. C is a thin stratum of metal, which is kept in the fire to surround the loop. D shows the loop itself in progress.

When the fire is hot, the first operation is to melt down a portion of pig iron, say 50 to 70 pounds, according as the pig contains more or less carbon; the charcoal is then pushed back from the upper part of the fire, and the blast, which is then reduced, is allowed to play upon the surface of the metal, adding from time to time some hammer slack, or rich cinder, the result of the previous loop. All these operations tend to *decarbonise* the metal to a certain extent; the mass begins to thicken, and at length becomes solid. The workman then draws together the charcoal and melts down another portion of metal upon the cake; this operation renders the face of the cake again fluid, but the operation of decarbonisation being repeated in the second charge, it also thickens, incorporates itself with the previous cake, and the whole becomes hard; metal is again added until the loop is completed. During these successive operations, the loop is never raised before the blast, as it is in making iron, but it is drawn from the fire and hammered into a large bloom, which is cut into several pieces, the ends being kept separated from the middle or more solid parts, which are the best.

This operation, apparently so simple in itself, requires both skill and care; the workman has to judge, as the operation proceeds, of the amount of carbon which he has retained from the pig iron; if too much, the result is a very raw, crude, untreatable steel; if too little, he obtains only a steelified iron; he has also to keep the cinder at a proper degree of fluidity, which is modified from time to time by the addition of quartz, old slags, &c. It is usual to keep from two to three inches of cinder on the face of the metal, to protect it from the direct action of the blast. The fire itself is formed of iron plates, and the two charcoal bottoms rise to within nine inches of the tuyere, which is laid flatter than when iron is being made. The position of the tuyere causes the fire to work more slowly, but it insures a better result.

The quantity of blast required is about 180 cubic feet per minute, at a pressure of 17 inches water gauge. Good workmen make 7 cwt. of steel in 17 hours. The waste of the pig iron is from 20 to 25 per cent., and the quantity of charcoal consumed is 240 bushels per ton. The inclination of the tuyere is 12 to 15 degrees. The flame of the fire is the best guide for the workman. During its working it should be a red blueish colour. When it becomes white the fire is working too hot.

From this description of the process, it will be evident that pig iron will require a much longer time to decarbonise than the cakes of metal which have been roasted, as already described; and, again, it must be evident, that a *purified* and *decarbonised* metal, such as I have proposed, must be the best to secure a good and equal quality to the steel, since the purified metal is more homogeneous than the crude iron.

When, therefore, care has been taken in melting down each portion of metal, and a complete and perfect layer of steel has been obtained after each successive melting, when the cinder has had due attention, so that it has been neither too thick nor too thin, and the heat of the fire regulated and modified during the progressive stages of the process, then a good result is obtained; a fine-grained steel is produced, which draws under the hammer, and hardens well. However good it may be, it possesses one great defect; it is this. During its manufacture, *iron* is produced along with the steel, and becomes so intimately mixed up with it, that it injures the otherwise good qualities of the steel; the iron becomes, as it were, interlaced throughout the mass, and thus destroys its hardening quality. When any tool or instrument is made from natural steel, without it has been very well refined, it will not receive a *permanent* cutting edge; the iron part of the mass, of course, not being hard, the tool cuts only upon the steel portion, the edge very soon, therefore, becomes destroyed. There is another defect in natural steel, but it is of less importance. When too much carbon has been left, the steel is raw and coarse, and it draws very imperfectly under the hammer; the articles manufactured from such steel often break in hardening; thus it is evident, that in producing the steel, every care, skill, and attention are required at the hands of the workman. These defects very materially affect the commercial value of the steel; the irregular quality secures no guarantee to the consumer that the tools shall be perfect, and, consequently, it is not used for the most important purposes; yet, where the raw steel is refined, it becomes a very useful metal, and is largely used in Westphalia for the manufacture of hardware, scythes, and even swords. It possesses a peculiarity of retaining its steel quality after repeated heating, arising from its carbon being, as it were, incorporated with *each* molecule of the mass. This property renders it very useful for mining and many other purposes.

The raw steel, being so imperfect, is not considered so much an article of commerce with the manufacturer, but it is sold to the steel refiners, who submit it to a process of welding. The raw steel bloom is drawn into bars, one or two inches wide and half an inch thick, or less; a number of these are put together and welded; these bars are then thrown into water, and they are broken in smaller pieces to examine the fracture; those bars which are equally steelified are mixed together. In manufacturing refined steel, the degree of hardness is selected to suit the kind of article which it is intended to make. A bar, two to three feet long, forms the top and bottom of the bundle, but the inside of the packet is filled with the small pieces of selected steel. This packet is then placed in a hollow fire, and carefully covered from time to time with pounded clay, to form a coat over the metal, and preserve it from the oxidizing influence of the blast. When it is at a full welding heat it is placed under a hammer, and made as sound and homogeneous as possible; it is again cut, doubled together, and again welded. For very fine articles, the refining is increased by several doublings, but this is not carried at present to so great an extent as formerly, since cast steel is substituted, being in many cases cheaper. Although the refined natural steel is very largely consumed in Germany, and also in Austria, yet a considerable quantity is exported to South America, the United States, and to Mexico. The Levant trade takes a large portion, and is supplied from the Styrian and Carinthian forges. This is shipped from Trieste; it is sold in boxes and bundles. That in boxes is marked No. 0 0, up to 4. The 0 0 is the smallest, being about ¼ in. square; number 4 is about ½ in.; 0, 1, 2, and 3, being the intermediate sizes. It is broken in small pieces, about 3 to 7 inches long. In bundles of 100 lbs. the steel is drawn to various sizes, and is so packed. A large portion is sent to the East Indies, and also to the United States. For this kind of steel Halbach enjoys a high reputation, also Hassenclever, both Westphalian manufacturers.

The average price of that sold in boxes is £20 to £24 per ton; in bundles, £17 to £20; and the raw steel, as sold to the refiners, £15 to £18 per ton: whilst the refined steel increases in price according to the number of times it has been refined.

I take the manufacture of puddled steel as next in order, because the product is similar to that of natural steel, that being obtained direct from the crude pig iron. It is a steel of very recent invention, and its manufacture is carried on entirely in Westphalia. But a few years ago a very small quantity of this steel was produced from *one* work. There are now several large establishments for its manufacture. The produce is becoming considerable, and likely to increase on account of its cheapness.

The object of the operation is similar to that adopted in the making of raw steel, to decarbonize pig iron down to that point at which it can be treated as steel. The process is this. About 280 lbs. of pig iron are charged into a puddling furnace. As soon as this metal begins to melt the damper is partly closed, and 12 to 16 shovelsful of cinder, &c., as it comes from the hammer and rolls, are thrown into the furnace; the whole is then melted down together, and the mass is puddled with great care. The metal having become so far decarbonized as to lose its liquidity, the damper is opened, and 40 lbs. of pig iron are charged near the fire-bridge of the furnace. This is allowed gradually to melt and mix itself with the metal previously charged, which causes it to boil; a blue flame rises from the surface of the mass, and very shortly the metal stiffens. The damper is again three-quarters shut, and the mass is worked until it becomes waxy. The metal is then collected into balls and hammered into blooms. This steel is very imperfect; too much depends upon the manipulation of the process; it is out of the sight of the workman, and equally from under his control, being continually covered with cinder. Practice has, no doubt, assisted materially in the improvements made in the manufacture of this steel since its introduction, but it is evident that steel produced by such a process can only be serviceable for the commonest purposes, being subject to many serious imperfections. The blooms resulting from the process described are drawn, doubled, and welded precisely in the same manner as charcoal raw steel is refined; yet, such is the acknowledged inferiority of this steel, that whilst charcoal natural steel sells for £18 per ton, the puddled steel will not command more than £14 per ton, and an equal reduction is made on the refined steel manufactured from puddled steel blooms.

The next process is the Paal method, so called from the name of the works at which the plan is used. These works belong to Prince Schwartzenberg, and are situated near to Murrau, in Styria. The process is based upon the old one of Vanaccio; it consists in plunging iron into a bath of melted metal. The carbon of the metal combines with the iron, and in a very short time converts it into steel. This process was carried further by Vanaccio, who contrived to add wrought iron to the metal until he had decarbonised it sufficiently; this was found to produce a steel, but unfit for general use. That produced by plunging iron into metal was found to be very hard steel on the outisde, but iron within; while that produced by adding iron to the metal was found too brittle to be drawn. The Paal method, however, as I saw it used at these works, is a decided improvement in the manufacture of refined natural steel. They produce natural steel at the prince's various works, and bring it to Paal to be refined. The packets, as already described in the refinement of natural steel, are welded and drawn to a bar; whilst hot they are plunged into a bath of metal for a few minutes, by which the iron contained in the raw steel becomes carbonised, and thus a more regular steel is obtained than that produced by the common process. The operation requires great care, for if the bars of steel be left in the metal too long they are more or less destroyed, or perhaps entirely melted. It commands a little higher price in the market, and is chiefly consumed by the home manufacturers, excepting a portion which is exported to Russia.

I have now described the manufacture of steel by various processes, in all of which the carbon is derived from the metal itself, and in which the whole of the molecules of the metal may be said to be equally charged; they contain the necessary amount of carbon, or steelifying principle, within themselves, and to this may be attributed the reason why, after repeated heating and hammering, the steel never loses its property of hardening. On this account natural steel is used almost exclusively by the Mexican and South American miners for their tools.

I shall now turn to the second mode of producing steel, by introducing carbon into iron to such an extent as may be needful for the various purposes to which it is to be applied.

In explaining the theory and practice of manufacturing natural steel, I have shown that the object is to prevent the mass from becoming iron, the process being arrested at that point where the metal has lost so much of its carbon that the *remainder* is necessary for it to possess as a steel.

The process of converting iron into steel by cementation is the reverse of the process already described. The iron to be converted is placed in a furnace stratified with carbonaceous matter, and on heat being applied, the iron absorbs the carbon, and a new compound is thus formed.

When this process was discovered is not known. At a very early period charcoal was found to harden iron and make it a sharper cutting instrument; it seems probable that from the hardening of small objects bars of iron were afterwards submitted to the same process. To Reamur certainly belongs the merit of first bringing the process of conversion to any degree of perfection. His work contains a vast amount of information upon the theory of cementation; and although his investigations are in many instances not borne out by the practice of the present day, yet the *first* principles laid down by him are now the guide of the converter; our furnaces are much larger than those used by Reamur, and they are built so as to produce a more uniform and economical result; they give, however, precisely the same results which he obtained in his small ones.

A converting furnace consists simply of two troughs, built of fire-brick—12 feet long, 3 feet wide, and 3 feet deep; the fire-room is placed between them, and the whole covered by an arched vault, so that the heat may pass entirely around these troughs, and distribute itself equally. The bar iron is placed within these troughs, stratum superstratum along with charcoal, which is broken to the size of beans. When the troughs are full they are covered with sand or loam, which partially vitrifies and cakes together as the heat of the furnace increases, and thus, by hermetically sealing the top, the air is excluded. This furnace being charged with about 20 tons of iron, the fire is lighted, and in the course of 60 to 70 hours the iron will have become fully heated; *at this point the conversion commences.* The pores of the iron being opened by heat, the carbon is gradually absorbed by the mass of the bar, but the *carbonisation* or conversion is effected, as it were, in layers. To explain the theory in the clearest manner, let me suppose a bar to be composed of a number of laminæ—the combination of the carbon with the iron is first effected on the surface, and gradually extends from one lamina to another, until the whole is carbonised. To effect this complete carbonisation the iron requires to be kept at a considerable uniform heat for a length of time. Thin bars of iron are much sooner converted than thick ones. Reamur states, in his experiments, that if a bar of iron 3-16ths of an inch thick is converted in 6 hours, a bar 7-16ths of an inch would require 36 hours to attain the same degree of hardness. The carbon introduces itself *successively*, the first lamina or surface of a bar combining with a portion of the carbon with which it is in contact, gives a portion of the carbon to the second lamina, at the same time taking up a fresh quantity of carbon from the charcoal; these successive combinations are continued until the whole thickness is converted; from which theory it is evident that from the exterior to the centre the dose of carbon becomes proportionately less. Steel so produced cannot be said to be perfect; it possesses in some degree the defect of natural steel, being more carbonised on the surface than at the centre of the bar. From this theory we perceive that steel made by cementation is different in its character from that produced directly from crude metal. In conversion the carbon is made successively to penetrate to the centre of the bar, whilst in the production of natural steel, the molecules of metal which compose the mass are *per se* charged with a certain per centage of carbon necessary for their steelification; not imbibed, but obtained by the decarbonisation of the crude iron down to a point requisite to produce steel.

During the process of cementation, the introduction of the carbon disintegrates the molecules of the metal, and in the harder steel produces a distinct crystallisation of a white silvery colour. Wherever the iron is unsound or imperfectly manufactured, the surface of the steel becomes covered with blisters thrown up by the dilation of the metal and introduction of carbon between those laminæ which are imperfectly melted. Reamur and others have attributed this phenomena to the presence of sulphur, various salts, or zinc, which dilate the metal; but this is incorrect, because we find that a bar of cast steel which is homogeneous and perfectly free from internal imperfections never blisters, for although it receives the highest dose of carbon in the furnace, yet the surface is perfectly smooth. From this it is evident that the blisters are occasioned by imperfections in the iron. Iron increases, both in length and weight, during conversion. Hard iron increases *less* than soft. The augmentation in weight may be said to be $\frac{1}{200}$, and in length $\frac{1}{120}$, on an average.

The operation of conversion is extremely simple in its manipulation, nevertheless, it requires great care, and a long as well as a varied experience, to enable a manager to produce every kind or temper required by consumers. Considerable knowledge is required to ascertain the nature of the irons to be converted, because all irons do not convert equally well under the same circumstances; some require a different treatment from others, and, again, one iron may require to be converted at a different degree of heat from another. The furnace must have continual care, and be kept air-tight, so that the steel, when carbonized, may not again become oxidized. Generally speaking, in working converting furnaces, but little attention is paid to the theory of producing steel, which I have endeavoured to explain. It is known amongst steel-makers, that if iron be brought in contact with carbon, and if heat be applied, it will become steel. This is the knowledge gleaned up by workmen, and I may add, by too many owners of converting furnaces. The inconvenience arising from a want of care and knowledge of the peculiar state of the iron *during* its conversion, sometimes occasions great disappointment and loss. The success usually attained by workmen may, however, be attributable to an everyday attention to one object, thus gaining their knowledge from experience alone, good, I admit, in a workman, but this should not satisfy the principal or manager of a steel work. It is, perhaps, not needful that he should be a man of science, but I consider it the duty, as it certainly is the interest, of every owner of such works, not only to satisfy himself, but to be able to convince the minds of others, that he is fully conversant with the cause and effect of every operation in his business, and although a knowledge of chemistry may throw much light upon his operation, it is also necessary that he should possess a varied experience in conjunction with it, before he can pretend to produce steel of such superior and uniform quality as the arts require. The conversion, or carbonization of the iron, is the foundation of steel making, and, as such, may be considered as the first step in its manufacture. Before bar steel is used for manufacturing purposes, it has to be heated, and hammered or rolled. Its principal uses are for files, agricultural implements, spades, shovels, wire, &c., and in very large quantities for coach springs.

Bar steel is also used for manufacturing shear steel. It is heated, drawn to lengths 3 feet long, then subjected to a welding heat, and some six or eight bars are welded together precisely as described in the refinement of natural steel; this is called single shear. It is further refined by doubling the bar, and submitting it to a second welding and hammering; the result is a clearer and more homogeneous steel. During the last seven years the manufacture of this steel has been limited, mechanics preferring a soft cast steel, which is much superior when properly manufactured, and which can be very easily welded to iron.

The price of bar steel varies according to the price of the iron from which it is made, but, as a general average, its price in commerce may be taken at £5 per ton beyond the price of the iron from which it is made. Bar steel produced from the better irons is usually dearer than the commoner kind, on account of their scarcity.

Shear steel in ordinary size sells at £60 per ton nett.
Coach-spring steel from foreign iron, £22 ,,
Coach-spring steel from English iron, £18 ,,

These may be taken as approximate prices in 1854-5.

From the outline which I have given of the processes by which various steels are manufactured, it will be seen that that there are in each great defects, want of uniformity, temper, or clearness of surface, unfitting them for many useful purposes. To obviate these defects, both bar converted and also raw steel are *melted*, by which the metal is freed from any deleterious matter which the iron might have contained; a uniform and homogeneous texture is obtained, whilst an equality in temper or degree of hardness is secured; besides which the surface is capable of receiving a high, clear, and beautiful polish,—qualities which the other steels I have described do not possess. The first steel which may be called cast steel is the celebrated wootz of India; it is produced by mixing rich iron ore with charcoal in small cups or crucibles. These are placed in a furnace, and a high heat is given by a blast. After a certain time this ore melts and receives a dose of carbon from the leaves and charcoal charged with it. The result is a small lump of metal with a radiated surface about the size of a small apple cut in two; it is very difficult to work; nevertheless, swords and other steel implements are manufactured from it in the east; it is not found in England as an article of commerce. The melting of bar steel was first practically carried out by Mr. Huntsman, of Attercliffe, near Sheffield, whose son yet carries on its manufacture, for which he enjoys a very high celebrity, by making use of the best materials, and insisting upon the most careful manipulation of his steel in every process. The manufacture of cast steel is in itself a very simple process. Bar steel is broken into small pieces, which are put into a crucible, and are melted in a furnace about 18 inches square and 3 feet deep. The crucible is placed on a stand 3 inches thick, which is placed on the grate-bars of the furnace. Coke is used as fuel, and an intense heat is obtained by having a chimney about 40 feet high. Although a very intense white heat is obtained, yet it requires 3½ hours to perfectly melt 30lbs. of bar steel. When the steel is completely fluid, the crucible is drawn from the furnace, and the steel is poured into a cast-iron mould. The result is, an ingot of steel, which is subsequently heated and hammered, or rolled, according to the want of the manufacturers. Although I stated that the melting of cast steel is a simple process, yet, on the other hand, the manufacture of cast steel suitable for the *various wants* of those who consume it requires an extensive knowledge; a person who is capable of successfully conducting a manufactory, must make himself master of the treatment, to which the steel in manufactures will be submitted by every person who consumes it. Cast steel is not only made of many degrees of hardness, but it is also made of different qualities; a steel maker has, therefore, to combine a very intimate knowledge of the exact intrinsic quality of the iron he uses, or that produced by a mixture of two or three kinds together; he has to secure as complete and as equal a degree of carbonisation as possible, which can only be attained by possessing a perfect practical and theoretical knowledge of the process of converting; he has to know that the steel he uses is equal in hardness, in which, without much practice he may easily be deceived; he must give his own instruction for its being carefully melted, and he must examine its fracture by breaking off the end of each ingot, and exercise his judgment whether or not proper care has been taken; besides all this knowledge and care, a steel maker has to adapt the *capabilities* of his steel to the *wants* and *requirements* of the consumer. There are a vast variety of defects in steel as usually manufactured; but there are a far greater number of instances in which steel is *not adapted* for the manufacture of the article for which it was expressly made. Cast steel may be maufactured for planing, boring, or turning tools; its defects may be, that the tools when made crack in the process of hardening, or that the tool whilst exceedingly strong in one part, will be found in another part utterly useless.

Cast steel may be wanted for the engraver. It may be produced apparently perfect, and with a clear surface, but may be so improperly manufactured, that when the plate has been engraved and has to be hardened, it is found covered with soft places. The trial is even greater when the engraving is transferred by pressure to another plate. I might cite a vast number and variety of instances in which cast steel is manufactured by unskilful persons, and for want of a proper knowledge of the treatment which the steel will receive after it has left his control, it is found more or less *unsuitable.* It is, therefore, evident that a steel maker must not only attend to the intrinsic quality of his steel, but he has to use his judgment as regards the degree of hardness and tenacity which it should possess, so as to *adapt it to the peculiar requisites of its employment.* Now as to the prevention of the defects I have mentioned, although it is a task requiring much practical knowledge, yet it is attained by many who, having combined a knowledge of their own business with that of their customers, have gradually earned for themselves a deserved reputation.

The manufacture of cast steel is open to great temptations, which may be termed fraudulent. Swedish iron, as I have already stated, varies in price according to its usefulness for steel purposes; cast steel may, therefore, be manufactured from a metal selling at £20 a ton, whilst the price charged for it to the consumer presumes it to have been made from a metal worth £30 per ton. The exterior of the bar is perfect, the fracture appears to the eye satisfactory, and its intrinsic value is only discovered when it is put to the test; thus, whilst a steel maker has to exercise his knowledge, judgment, and care, he has a moral duty to perform, by giving to his customer a metal of the intrinsic value he professes it to be, and for which he makes his charge.

In manufacturing the commoner descriptions of steel, particularly cast steel made from English iron, oxide of manganese has been largely used; its use produces malleabillity to a common metal, and the effect upon the steel during the operation of melting has been a subject of much speculative discussion, not only amongst scientific men, but also at the bar. The great question of the late Mr. Heath's patent is now before the House of Lords for their final decision. I cannot agree with any of the causes which have been set forth during the various discussions in the courts of law, as producing the effect every day obtained. I find no alloy of metallic manganese with steel, and certainly the very small quantity of carbon which the oxygen of the manganese takes up affects the degree of hardness very slightly.

I have examined this interesting matter, and in doing this I have set up no theory of my own, but I have carefully examined the scoria or slag produced, when oxide of manganese was used, and when it was not; the metal also has been carefully weighed before and after melting. In my experiments I used English iron, which is so coarsely manufactured that it is mixed up with much deleterious matter. In more nicely investigating this subject, I used a Swedish iron, which contained a large amount of silicate of iron. I charged two crucibles each with 30lbs. of this Swedish metal properly converted into steel. Into one I put 3 per cent. of oxide of manganese—into the other nothing. Both crucibles were in one furnace, and melted down in about the same length of time. In the crucible containing the oxide of manganese I got more slag and a little less metal than in the other. The ingot melted with manganese drew very sound under the hammer; the other was filled with cracks. On an examination of the metal and the slag resulting from each crucible, I found that the oxide of manganese had attacked and dissolved all the silicate of the metal it could find, as the metal gradually melted, and converted it, with other deleterious matter, into a glassy slag, which was very fluid. The steel being thus freed from these noxious matters, is precipitated by its own gravity, and the molecules of metal coming in closer contact by the removal of the foreign matter, which before more widely divided them, the metal is of greater density, and becomes very malleable under the hammer. There have been various attempts to produce a cast steel from the rich iron ores by converting them and subsequently melting, but although cast these can of course be so obtained, yet it has no defined temper or steel quality. Charcoal also has been added to bar-iron cut into small pieces, but although steel is thus obtained, the same ingot produces several different degrees of hardness, and sometimes ingots of no value whatever. The experiments of Cluoet, Mushet, Briant, and others, have equally been productive of no useful result.

I have endeavoured in the foregoing to give a clear, and at the same time a condensed description of the raw materials required, and the processes used, in the manufacture of each kind of steel found in commerce, either in England, the continent of Europe, or America, which concludes the first part of this essay.

In contrasting the steel manufacture of England with that of America and the continent of Europe, I propose first, to form an estimate of the *weight* of steel manufactured in each country, and of *its value* as an article of commerce; secondly, to show that England produces a greater weight of steel than the whole of the continent of Europe and America, and also, by a comparison of the degree of perfection attained in each country, to prove that whilst England produces a greater weight of steel, she also eminently excels other countries in her knowledge of this branch of manufacture.

From these two heads I shall show the importance of this branch of our industrial commerce as a source of wealth to the nation, and contrast the high superiority of the various steels made in England with those produced in other countries, proving not only that the annual value is of importance to us as a manufacturing community, but that our scientific knowledge and practical skill have placed us very greatly in advance of other nations in the production of steel.

The following Table shows the production of steel in France:—

Year.	Raw Steel.	Converted Steel.	Total Production.
	Tons.	Tons.	Tons.
1826	3,257	1,500	4,757
1835	2,949	3,308	6,257
1840	3,546	3,859	7,405
1841	3,202	3,684	6,886
1842	3,527	5,812	9,339
1844	3,212	7,782	10,994
1845	4,004	8,369	12,373
1846	4,408	8,546	12,954

The manufacture of steel in France is considerable. They produce natural steel from the white iron of Dauphiny, and the metal produced from the spathose ores, which latter they import. The manufacture of converted and cast steel, has, during the past ten years, become important. The principle works are situated at St. Etiénne, at which Swedish iron is mostly used, as at Sheffield. Although the French produce a considerable weight of cast steel, yet its quality is by no means equal to that produced in England, since English cast steel is now largely imported, particularly for superior purposes.

Of the above it must be noticed that the raw material is not the manufacture of the country, but a large portion is imported from Sweden, yet the Table shows the weight of steel produced annually in this country.

In 1846, the produce is estimated at 12,954 tons, of which 4,408 were raw or natural steel, and 8,546 converted steel.

There is no return of refined steel, but as it is manufactured from the raw steel, it does not affect the statistical account. Cast steel being only made by two or three houses in France, the weight is not to be exactly obtained.

The raw steel is higher in France than in other countries, as it is protected by the import duties. I estimate it at £25 per ton.

The weight of cast steel I estimate in round numbers at 2000 tons, which I value at £60 per ton, on account also of the protective duty. The iron for this production is imported.

The value of the steel produced in France is

	£	s.	d.
12,954 tons natural and converted steel, at £25 per ton	323,850	0	0
2,000 tons cast steel, at £60 per ton .	120,000	0	0
14,954 tons.	£443,850	0	0

In the Prussian dominions the major part of the steel produced is manufactured in Westphalia, around Remscheid, Lohngen, and Hagen. A portion is made in Silesia, Thuringia, and the Brandenburg district, in which there exist several converting furnaces.

The produce of the kingdom is as follows :—

Year.	Raw Steel.	Refined Steel.	Cast Steel.
1837	103,938	42,472	682
1838	101,820	60,308	818
1839	100,526	56,309	727
1840	97,930	68,602	636
1841	100,697	69,496	909
1842	95,926	61,483	909
1843	107,730	60,794	909
1844	100,642	68,391	1,500
1845	109,427	70,480	1,750
1846	81,966	47,449	1,223
1847	112,672	54,209	4,357
1848	105,276	51,644	5,069
1849	88,040	53,661	11,121
1850	107,674	68,379	17,645

These Weights are in Prussian Zentners.

In this Table the converted steel is included in the weight of raw steel, from which material both refined and cast steel are produced.

The number of furnaces employed to produce this steel are, 143 charcoal fires, or refineries for raw steel; 105 furnaces for refining raw steel; 7 converting furnaces; 58 melting holes, or furnaces.

In 1850 the Brandenburg district produced 3160 zentners of converted steel.

	Zentners.	
Silesia produced . .	1,630	raw steel
Sax Thuringia . .	4,918	do.
Westphalia . . .	41,261	do.
,, . . .	57,220	refined steel.
,, . . .	17,336	cast steel.
Rhenish Prussia . .	56,605	raw steel.
,, . . .	11,159	refined steel.
,, . . .	309	cast steel.

The refined steel is largely used in the manufactures of the country; a further quantity is exported to the United States of America, to France, and to Spain. The raw steel is used for common purposes. The cast steel is principally made into railway springs and axles. The refined steel is of course manufactured from the raw steel.

In estimating the value of the whole produce, I deduct the waste of metal which arises from the refining process so as to obtain the nett remainder of raw steel; this waste I estimate at 15 per cent. upon the weight produced in 1850, 68,379 cwt.; this will consume 78,634 cwt. Also, cast steel made both from raw and converted steel.

Of the 17,645 cwt. manufactured, I estimate 10,000 cwt. as produced from raw steel, and 7,645 from converted steel. 88,634 cwt. of raw steel is therefore consumed in the manufacture of refined steel and cast steel, leaving 19,040 cwt. for common uses, or exportation.

I estimate the whole of these products as follows :—

Cwt.		Tons.		
68,379	or	3,419	refined steel, at 100 dols. per 1,000 lbs. Prussian, or £30	£112,570
17,645	or	882	of cast steel at £45 per ton	£39,690
19,040	or	952	raw steel, at 65 dols. per 1000 lbs. Prussian, or £19 10s. .	£18,564
		5,253 tons.		£170,824

The weight of pig iron consumed in Austria in 1848 was 368,000 cwt., equal to about ten per cent. of the whole product of the blast furnaces of that country, including Hungary. This metal produced 287,300 cwt. of raw steel, of which 80,000 to 90,000 cwt., or 4,500 tons, were consumed in the country in the form of steel, more or less refined, for the manufacture of scythes, files, and tools, besides the raw or common steel used for agricultural implements and the like.

The exportation in five years, from 1843 to 1847, was equal to 87,120 cwt., or 4,356 tons, shipped from Trieste to the Levant, Mexico, and South America.

The product of converted steel in 1848 was 125 tons; the product of cast steel in 1848 was 210 tons, obtained chiefly from the melting of raw steel.

From the above statement the product of refined steel is 8,856 tons, and 15 per cent. for waste in producing it from raw steel; and I find it requires 10,184 tons to produce it, leaving 4,181 tons of raw steel for common purposes, named above.

I estimate the whole produce of Austria as follows :—

Tons.		£	s.	d.
4,500	refined steel, for manufacturing in the country, at £30 per ton .	135,000	0	0
4,356	steel exported, all sizes, averaged at £24 per ton	104,544	0	0
4,181	raw steel, used for common purposes, £19 10s. per ton . . .	81,529	0	0
13,037 Tons.		£321,073	0	0

Sweden produces both keg and steel in faggots, which is chiefly shipped to the East Indies. The demand is very variable for this steel, and whilst at one time a considerable quantity may be produced if the demand is brisk, at another their forges produce iron, which they can at all times either sell or send to the general depot at Stockholm.

Denmark, Holland, Spain, Portugal, Sardinia, and Italy, produce no steel of importance.

In the United States of America raw or natural steel is not produced; the only kind at present manufactured is converted steel, produced from the Russian and Swedish irons so largely imported by them. In a country which is advancing so rapidly it is impossible to form any distinct estimate of the weight manufactured, but from my personal knowledge of the extent of it I consider that 10,000 tons is a large estimate. Several attempts have been made to produce cast steel in New Jersey and Pittsburg, but hitherto without success.

The American blister steel is quoted at 5 cents per lb., or 102 dols. per ton, which, at 8 per cent. exchange, is equal to about £21 5s. per ton ; on 10,000 tons this would represent a value of £212,500.

The manufacture of steel in England is chiefly confined to Sheffield, although it is also made at Newcastle and in Staffordshire. I have already shown, in the early part of this essay, that the importation of Swedish iron, combined with that furnished from English materials, amounts to from 40,000 to 50,000 tons per annum; of course this weight represents the quantity of steel manufactured of every description.

Mr. Scrivenor estimates the number of furnaces in Sheffield and its neighbourhood as follows:—

	Converting Furnaces.	Cast steel Furnaces. or holes.
1835	56	554
1842	97	774
1846	105	974
1853	160	1495

Now a converting furnace will produce 300 tons of steel per annum, but if I estimate each to produce 250 tons, 160 converting furnaces would represent a make of 40,000 tons of steel a year in Sheffield alone. Again, he says there are 1495 melting holes; now each furnace of 16 holes will melt 200 tons; this, therefore, shews a product annually of 29,900 tons, but as such furnaces may not all be in continual work from various causes, I have estimated the quantity of cast steel manufactured in Sheffield at 23,000 tons. The weight of coach spring steel, I have estimated at 10,000 tons, leaving a remainder of 7000 tons of bar for the manufacture of German, faggot, single and double shear steel. As regards the price, I take cast steel at 45*l.* per ton; its commercial value varies from 35*l.* to 60*l.* per ton nett, and as a large quantity of the cheaper steel is sold, I have fixed 45*l.* per ton on an average. The price of bar steel is below the real value, since it includes all shear steel, the best of which sells at 60*l.* per ton, whilst, however, a portion of this 7000 tons sells only at 28*l.*, and some even lower. The price of coach springs is the price now paid for them.

I estimate the weight and value of the steel made in England as follows:—

Tons.		£.	s.	d.
23,000	of cast steel, all qualities, at £45 per ton	1,035,000	0	0
7,000	bar steel, including German, faggot, single and double shear steel, average £35 per ton	245,000	0	0
10,000	coach-spring steel, £19 per ton	190,000	0	0
40,000 Tons		£1,470,000	0	0

From the foregoing statistics, we find that

				£	s.	d
France	produces	14,954 tons,	average value of	443,850	0	0
Prussia	,,	5,453 tons,	,,	170,824	0	0
Austria	,,	13,037 tons,	,,	321,073	0	0
United States	,,	10,000 tons,	,,	212,500	0	0
England	,,	40,000 tons,	,,	1,470,000	0	0

Such is the contrast of the manufacturing power of the steel-producing countries; it shows the eminent position of England, in both weight and value; this can only arise from the practical skill and scientific knowledge which we have brought to bear upon its manufacture; and the active energy which has enabled us to produce steel *suitable for every purpose in the arts.* This superiority not only enables our manufacturers to maintain the high position they now hold, but to increase it yet further; for we daily see our production expanding, not only to supply the wants of our home manufactures, but also for the continent of Europe, as well as the United States of America and Canada.

In conclusion, I may add, that whilst it is a business which affords a fair manufacturing profit to those who have embarked in it, it also adds very largely to the wealth of the empire. The working-classes also enjoy its benefits; independent of the well-paid labour required to produce steel to the value of one and half millions sterling, it gives occupation to the collier by causing a consumption of 120,000 tons of coals annually. I add

A LIST OF THE DUTIES IMPOSED BY VARIOUS COUNTRIES UPON STEEL.

The Zollverein	1 dollar, 15 silver groschen per cwt.
Austria	4 florins, per Vienna centner.
Belgium	80 centimes per 100 kilogrammes, about 2 cwt.
France	£13 4s. 0d. per ton on bars, £32 per ton on sheets.
Sweden	Cast steel, 6 rix-dollars; refined steel 15 rix-dollars; raw and converted steel, prohibited.
Russia	75 copecks per pood, = to 36lbs. English.
Holland	20kreutzers per Dutch centner.
United States of America	15 per cent. ad valorem on cast, shear, German, &c., in bars; and 20 per cent. ad valorem on sheet and blistered steel.

DISCUSSION.

Mr. Harry Scrivenor, in a letter to the Secretary, says, "The process of the manufacture of steel is generally but little known in this country, but it is, and is still more becoming, a most valuable addition to our home manufacture. And it is with somewhat a proud feeling we may say, that while we almost monopolise the make of iron, we can also so far naturalise the make of steel that in its production we are enabled to leave all other countries far behind us." * * * "The great improvement in the manufacture of steel is stated by Dr. Ure to have originated with Mr. Josiah M. Heath, who took out a patent in 1839. One immediate consequence of his discovery was a reduction in the price of good steel in the Sheffield market of from 30 to 40 per cent. His claims have been disputed, and Mr. Sanderson says the great question of the late Mr. Heath's patent is now before the House of Lords for their final decision. Mr. Heath's patent introduced a portion of carburet of manganese into the melting-pot, along with the usual bars of blistered steel, and he found that a common bar steel, made from an inferior mark or quality of Swedish or Russian iron, would, when so treated, produce an excellent cast steel. I was lately speaking to a steel-manufacturer of Sheffield on the subject of this patent. He said we use no manganese in our improvements, and the steel was made from English materials. Some years back I was connected with a company which had steel works, and the principal foreign iron which they used was a celebrated Russian make (the Demidoff mark). This mark is not mentioned by Mr. Sanderson; but from an observation he makes that, "in the manufacture of common steel, particularly that for *railway springs*, a very large quantity of steel iron is produced from English materials." I am led to suppose that the Russian iron has in a great degree been superseded by English improvements, as the principal sale of the steel made from the above was for *coach springs*. If I am right, it is a great step in advance, and certainly the imports of iron from Russia have very materially decreased of late years."

The Chairman remarked that the paper they had heard read that evening was of so comprehensive a character as to leave little room for more to be said upon the subject. It was extremely gratifying to have a paper of this kind, because, it would be remembered, that the Society of Arts had on various occasions encouraged improvements in the manufacture and use of steel; he more particularly alluded to the premiums offered by the Society for a cast trowel, and also the improvement in the adaptation of steel plates to engraving purposes; those beautiful engravings with which the Annuals and other books were adorned, were in the first instance encouraged and promoted by the Society of Arts. Although the art of engraving on steel was probably known to Albert Durer, yet the Society of Arts took a very prominent part in the improvements in steel engraving for printing purposes. He need not say one word upon the value of steel for many purposes in the arts. He would only allude to the familiar instance of the balance-spring of a watch, specimens of which were before him—one weighing half a grain, and another about a quarter of a grain—whilst in some parts of the movements the springs did not weigh more than the tenth part of a grain; and every gentleman was aware of the value of the balance-spring of his watch whenever he had the misfortune to break it.

A Gentleman wished to ask Mr. Sanderson whether he had used peat charcoal in the manufacture of steel, and with what results?

Mr. Sanderson said he had used peat charcoal in the manufacture of iron in the common charcoal refinery, and he had made a ton of iron of good quality and with less fuel than when wood charcoal was used.

Mr. Isaac Dodds (of Rotherham) directed attention to a variety of specimens of edged tools, and also English iron, manufactured under a new patent for effecting a partial steel conversion, upon the case hardening principle. The files exhibited were forged and cut in the *iron*, and subjected to the steeling or case hardening process. The material used was simply a mixture of charcoal with some of the bicarbonates and a little soda ash. He did not say they were superior to the cast steel files, but they answered all the purposes, and were produced at less cost, although they were an article that was scarcely as yet in the market. The same process, he said, also extended to the making of other cast steel tools, and also in the manufacture of railway axles and rails. Allusion had been made to the use of manganese in the manufacture of cast steel. He begged to state, that by Dodds' patented process manganese was not employed, and the grain of the metal was clearer, with less scoria and less liability to fracture than under the old process, besides which the steel was more easily tempered than that in which manganese was used. Some cutting tools were of such dimensions that they could not be made of steel, because the contraction was so great that they would break in the hardening, and here again, the process he had described applied, and by the same means an improvement had been made in the manufacture of steel wire, by which an article was obtained equal to that which was manufactured abroad. The process had become so uniform in its character, that garden tools, cutting tools, including augurs, &c., had been manufactured by it. He had nothing to add to Mr. Sanderson's paper, as that gentleman had probably a much greater practical acquaintance with the subject than he (Mr. Dodds) could lay claim to, his object being merely to call attention to an article that was as yet scarcely in the market, but which, it was believed, would have very general application.

Mr. Richard Knight observed that the statement made by Mr. Sanderson, that, in order to obtain steel of a good quality, the iron from which it is converted should of itself be of a certain degree of purity, was borne out by the magneto-electrical experiment of placing two bars of good quality iron in the dip of the magnetic meridian, and rotating a soft iron armature in the immediate vicinity of their poles. By this arrangement a very considerable deflection of the galvanometer needle was obtained upon making the necessary connection with that instrument. The iron bars were than removed and subjected to a process of decarbonisation, when they were again placed in the magnetic dip, and similarly treated in connection with the galvanometer, when an increased deflection of the needle was obtained. On the other hand, should the iron bars upon removal be subjected to a process of carbonisation, or in other words be converted into steel, then upon similar treatment in the magnetic dip a decrease would take place in the deflection of the galvanometer needle. But should these experiments be attempted with iron of bad or impure quality, they would be found very unsatisfactory if not entirely to fail, as the carbonisation as well as the decarbonisation of impure iron was attended with great uncertainty as to the results.

Mr. Siemens was not prepared to enter into a discussion of the paper, but it might not be uninteresting to state to the meeting some new applications of steel which had come under his notice. In visiting the workshops of his friend Mr. F. Crupp (of Essen, in Westphalia), he had seen steel applied in large bulks to the various parts of machinery, such as railway axles, and railway tyres, the latter being formed of cast steel in a very ingenious manner. A flat bar of steel was taken, two holes were bored in the ends of the bar, and by powerful machinery it was cut through from hole to hole. It was then opened out, and between rollers a perfect tyre was made without a weld. He had seen one tyre which, after running 30,000 miles, presented scarcely any appearance of wear on its surface. Another application of steel was to railway axles and crank axles of locomotive engines, where again the metal was called upon to sustain a great amount of wear and tear. He thought in all these cases the very best metal ought to be used, which in the end would always be found the cheapest, the excessive value of the steel being more than compensated by the greater load that could be put upon it, and by the much reduced wear and tear. Mr. Crupp was known to the British public by the steel gun, and the large steel rollers for rolling mills, which were so favourably noticed at the Great Exhibition.

Mr. Dodds remarked, that the steeling of the tyre of railway wheels was not a novel process, but had been patented some time ago by Mr. Sidney Jessop, but the cost was greater than some railway companies liked to incur, although he believed a great many tyres of that description were now in use. There was this advantage in them, they had all the toughness of the inner part of the tyre with all the additional wearing power of the outer portion of the tyre; and it was the same with axles, which could be supplied up to twenty tons weight. He would be happy to submit one of the axles to the inspection of the Society. The same method was now applied to the manufacture of spring steel, and he had been told they were very excellent.

Mr. Griffiths said, it would be desirable if some gentleman acquainted with the subject would explain the means by which it could be ascertained when steel was of a proper quality adapted for particular manufactures. They knew that in the manufacture of steel it assumed from time to time a variety of prismatic hues, from the pale straw-colour up to the dark blue. For his own part he was not acquainted with any index for such operations, and he thought a few facts on that subject would be interesting to the meeting.

The Chairman said, that rather related to the tempering of the steel by the workman than to its manufacture.

Mr. Sanderson explained that steel was hardened by being, when in a heated state, suddenly plunged into cold water or oil, which produced expansion, although some persons called it contraction, but it was in fact expansion. The steel was then too hard for any purpose. It was afterwards put into a fire and gently heated, and it then came to a straw colour, applicable to one purpose, or to a blue colour, applicable to another purpose; but the workman, by daily and constant practice, by observing the oxidisation on the surface of the metal, knew when the coat was sufficiently tempered to preserve the elasticity required for the purposes to which it was intended to apply the tool.

The Chairman than proposed a vote of thanks to Mr. Henderson for his excellent paper, which was passed by acclamation.

The Secretary announced that the paper to be read at the meeting on Wednesday next, the 16th inst., was on "The Capabilities for Mercantile Transport Service of Steam Ships," by Mr. Charles Atherton.

INTERNATIONAL COMMERCIAL LAW.

REPORT OF THE SUB-COMMITTEE.

A copy of the following report was placed in the hands of the President of the Board of Trade, by the deputation which waited upon him, as reported in the Journal of 6th April.

REPORT.

The Sub-Committee appointed to report on the desirableness of an application being made to the Board of Trade to support the propositions for a Congress at Paris, now under the consideration of the French Government; and on the particular points to be urged upon the President of the Board of Trade by such deputation; and also to enquire at the Foreign Office whether there are any means of ascertaining the general nature of the internal questions of commercial law which occur between British subjects and the subjects of Foreign States abroad, and whether such questions are frequently brought under cognizance of the British embassies and consulates; and further, to inquire at the Colonial Office whether the expediency of assimilating the colonial law has been considered, or any steps taken in relation thereto,—have now to report that with reference to the Colonial Department they learn that no particular measures have been prepared, or are at present contemplated in that department, for the assimilation of the divers laws now in force within our Colonies.

It appears probable, that in some of them, the laity, as well as the lawyers,within the Colonies, would be prepared to maintain, in respect to some of the laws, that they have the advantage over the English laws, and that the Department would not be prepared to dispute that advantage, or to rely on the opinion of English practising lawyers as to the superiority of their own law and practice. In this position, there would appear to be an advantage in referring the question of superiority of particular portions of substantive law to the examination of merchants, or competent and impartial laymen of different countries, aided by jurists, but by the appointment of English Law Officers the process of assimilation is quietly extending itself.

From the Foreign Office the Sub-Committee have not yet obtained the detailed information they seek; but they learn generally that a certain amount of correspondence is entailed upon that office by the differences in commercial law, domestic and foreign. The Sub-Committee still propose to pursue those inquiries.

The Sub-Committee also report that from inquiries made they learn that the report of the Mercantile Law Commission is now in a forward state, and will be presented to Parliament during the present session, and that it is probable it will be favourable to the expediency and practicability of the assimilation of the commercial laws of the United Kingdom.

The Sub-Committee have further to report that it is expedient that a deputation should wait upon the Board of Trade, for the purpose of presenting to the Right Honourable the President, the influentially-signed memorial praying that Her Majesty's Government will support the proposition already entertained by the French Government, of holding in Paris, during the ensuing summer, a Congress upon International Commercial Law.

Upon a general review of the subject, the Sub-Committee are of opinion that the following points should be specially pressed upon his attention, being of a practical character, interesting to the commercial classes, and such as it would be most desirable in the first instance to bring before the proposed Congress.

Partnership en Commandite.—Although much has been written on this subject, and its introduction into this country is extensively demanded, the real practical working of such partnership in Europe and America is not sufficiently known.

Anonymous Partnerships.—The authority for the formation of such partnerships in different States being in the hand of Government, much difficulty is generally experienced in obtaining it, whilst the cost in many countries is great.

Bills of Exchange.—The laws of different nations in respect to these instruments (essentially of an international character), prescribe different forms, and subject them to various legal incidents. Thus, where the Code Napoleon prevails, and elsewhere, a bill must be drawn in one place and be made payable in another, and must also contain certain words and indications which in England are not required. Under that code, bills must be accepted by name and in writing on the bill. In England, a foreign bill may be accepted by any word implying acceptance, and even by an instrument, as a letter or any paper, detached from the bill. An indorsement in some countries must be in full, in others, as in this country, it may be "in blank," by the mere signature on any part of the bill. The days of grace also differ in many towns and states.

Shipping.—In this country the ship owner's liability for the acts of the master is unlimited. In others it is limited to the ship and freight, and in others the owner has a right to abandon the ship when he declines to acknowledge the expence of the repairs, &c., by the master. The value of bills of lading is greater in other countries than in this.

Marine Insurance.—Many of the practices at Lloyd's are different from the insurance practice at Hamburg and other states. In some countries an insurance on profit, freight, and wages of seamen is prohibited, and in others it is permitted.

Bankruptcies.—A better system for international communication in regard to the rights of creditors to notices of meetings, dividends, &c., seems necessary. In the constant changes effected in our bankrupt law we might with advantage examine the foreign systems, the mode of division of assets, the classification of debts with different claims of precedence, the amount of restraint or punishment inflicted on fraudulent bankrupts, the value of acts done in view of bankruptcy, and the publication of the main causes of bankruptcy being all subjects of great importance.

Imprisonment for Debt.—The right of creditors on the person of the debtor, differing widely in many states, might advantageously be inquired into.

Law of "Foreign Attachment."—How far such a law exists on the Continent as it does in the city of London, and what are its principal objects and privileges, is a matter for inquiry.

Tribunals of Commerce.—It would be important to ascertain what is the best mode of settling commercial disputes, whether by the regular or exceptional courts—the constitution and practice of Industrial courts, such as the Court of "Prud'hommes;" also how far the principle of arbitration is acted on abroad, whether by forced or voluntary means. All such inquiries would facilitate the amendment and assimilation of International Commercial Law.

International Patentright and Copyright, Monies, Weights, and Measures, and the Laws of War relating to Commerce are also of great importance, and would form appropriate subjects of discussion at the proposed congress in Paris; but their being of a political character, and dealt with by treaty, the consideration they demand is probably greater than could be bestowed on them in connection with the more limited topics of international Commercial Law.

Proceedings of Institutions.

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LONDON.—From the fifth annual report of the London and South Western Railway Literary and Scientific Institution, it appears that the receipts during the year amounted to £254 15s. 4d. This is greatly in excess of the previous year, due to the extended working of the classes and the maintenance of the library; but the balance to the credit of the present year shows a small increase on that of the former year, being £25 11s. 0d. as against £21 5s. 5d. The evening school has enrolled no less than 68 boys; at a certain period the schoolroom was incapable of accommodating more than 30 of that number, but the removal of the school to a larger room has removed this difficulty, and there are now 76 on the list. By the liberality of the directors of the Railway Company, the whole of Brunswick-house, Wandsworth-road, has been fitted up and made available for the purposes of the Institution.

MEETINGS FOR THE ENSUING WEEK

MON. Geographical 8½. 1. Prof. Paul Chaix, "Notes on the passage of Hannibal across the Alps, and the valley of Beaufort, in Upper Savoy." 2. M. Susini, "The Amazon and the Atlantic water-courses of South America." 3. Copies of letters from Drs. Barth and Vogel, respecting the progress of the Central African Mission."
TUES. Pharmaceutical, 12 a.m. Anniversary.
Royal Inst. 3. Dr. Tyndall, "On Voltaic Electricity."
Civil Engineers, 8. Mr. L. E. Fletcher, "Description of the Landore Viaduct, on the South Wales Railway."
Pathological, 8.
WED. Society of Arts, 8. Mr. Charles Atherton, "The Capabilities for Mercantile Transport Service of Steam Ships, with reference to the Mutual relations of their Tonnage, Displacement, Engine Power, Steaming Speed, Distance to be run without re-coaling, Tons weight of Cargo conveyed, and the Expenses per Ton weight of Cargo."
Geological, 8. 1. Mr. A. K. Isbister, "Geological Notes on the British Possessions in North America, accompanied with a Geological Map." 2. Mr. W. Bray, "Notes on the Geology of Georgia, U.S." 3. Mr. C. Forbes, "On the Geology of the Coal-bearing Rock of the Middle Island, New Zealand."
THURS. Royal Inst. 3. Mr. G. Scharf, jun., "On Christian Art."
Antiquaries, 8.
FRI. Royal Inst., 8½. Mr. J. P. Lacaita, "On Dante and the Divine Commedia."
SAT. Asiatic, 2. Anniversary.
Royal Inst., 3. Dr. Du Bois Reymond, "On Electro-Physiology."
Royal Botanic, 3¾.
Medical, 8.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Delivered on 1st May, 1855.

Par. No.
65 (3). Trade and Navigation—Accounts (31st March, 1855).
93. Bills—Downing-street Public Offices Extension.
94. Bills—Woolmer Forest.
97. Bills—Dissenters' Marriages.
98. Bills—Friendly Societies (as amended by the Committee, on Recommitment, and on second Recommitment).
Public General Acts—Cap. 13, 14, 15, 16, and 17. (Delivered on 30th April, 1855.)

Delivered on 2nd May, 1855.

110. Local Acts (28. London and South-Western Railway; 29. Hartlepool Pier and Port; 30. West Somerset Mineral Railway; 31. Grand Surrey Canal; 32. Weymouth Waterworks)—Reports from the Admlralty.
100. Bills—Militia (No. 2).
101. Bills—Cinque Ports.

Delivered on 3rd of May, 1855.

197. Shipping—Returns.
202. Committee of Selection—11th Report.
205. Deficiency Bills—Return.
95. Bills—Personal Estates of Intestates.
102. Bills—Newspaper Stamp Duties (amended).
103. Bills—Carlisle Canonries,

Delivered on 4th of May, 1855.

110. Local Acts (33. Barrow Harbour; 34. Great Western and Brentford (Thames Junction) Railway—Reports from the Admiralty.
199. Turnpike Trusts (Ireland)—Abstract of the General Statements of Income and Expenditure.
92. Bill—Parish Constables.

Delivered on 5th of May, 1855.

200. Foreign Troops—Return.
203. State Carriages—Returns.
206. Revenue and Expenditure—Account.
210. Criminal and Statute Law Commissions—Returns.
213. Foreign Officers—Return.
214. Army—Return.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, May 4th*, 1855.]

Dated 23rd February, 1855.

400. J. Norton, Dublin—Cartridges.

Dated 1st April, 1855.

456. T. Kennedy, Kilmarnock—Wadding for firearms.

Dated 5th March, 1855.

491. C. L. Fowle, Massachusetts—Stitching machines. (A communication.)

Dated 9th March, 1855.

539. W. Smith, 10, Salisbury-street, Strand—Safety harness.

Dated 15th March, 1855.

583. N. Robinson, J. Lister, and H. Stevenson, Bradford—Looms for weaving cocoa-nut matting, &c.

Dated 26th March, 1855.

672. C. Armbruster, Andermach, and O. Laist, Pfeddersheim—Sulphate of soda.

Dated 28th March, 1855.

681. F. G. Mulholland, 44, Vincent-square, Westminster—Fire-proof and waterproof roofing, flooring, and covering.
683. J. Higgin, Manchester—Thickener for mordaunts and colours for printing woven fabrics.
685. W. Hutchinson, Tunbridge-wells—Artificial stone.
687. J. Revell, Duckinfield—Propelling vessels.
689. G. H. Nicholl, Dundee—Laundry stoves.
691. W. H. Gauntlett, Banbury—Apparatus for cutting tools.

Dated 29th March, 1855.

693. F. W. Mowbray, Shipley, near Leeds—Axle bearings.
695. F. J. Anger, 16, Stamford-street—Preservation of vegetable substances.
697. W. Brown, 5, Catherine-street, Cornwall-road—Sheet metal casks and kegs.
699. A. McDougall, Manchester—Consuming smoke.
701. A. Dalgety, Deptford—Steam engines.
703. R., W. W. and R. (jun.) Johnson, 4, Waterloo-place, Limehouse—Covering for surfaces, linings, roofs, &c.

Dated 30th March, 1855.

705. A. Bère, Lille—Steam boilers.
709. W. Tytherleigh, Birmingham—Covering iron with copper.
711. M. Prentice, Stowmarket, and T. Richardson, Newcastle-on-Tyne—Manures.
713. M. Prentice, Stowmarket, and T. Richardson, Newcestle-on-Tyne—Manures.
715. T. W. Bunning, Newcastle-on-Tyne—Steam engines.

Dated 31st March, 1855.

717. A. Shanks, 6, Robert-street, Adelphi—Hand drilling machines.
719. J. B. Surgey, Lidlington-place, St. Pancras—Threading needles.
721. R. Hardman, Bolton-le-Moors—Looms.
725. T. R. Crampton, Adelphi—Furnaces. (A communication.)
727. T. Hedgcock, R.N., 7, Cavendish-grove, Wandsworth-road—Quadrant.

Dated 2nd April, 1855.

529. F. Phillips, Downham, near Brandon—Distributing manure, sowing seeds, &c.
731. J. Taylor, Hounslow—Covers for books.
733. R. S. Newall, Gateshead—Standing rigging of ships.
735. G. W. Friend, 52, High Holborn—Umbrellas and parasols.

Dated 3rd April, 1855.

737. F. T. Botta, Paris—Beer brewing.
739. H. Chapman, Kingsland—Supplying and adjusting electrodes used in the production of electric light.
741. P. R. Jackson, Salford—Making patterns and moulding.
743. W. H. Tooth, 2, Pilgrim-street, Kennington-lane—Floating vessels and machinery, and steam signals.
747. J. Cowen, Greycoat-street, and J. Sweetlong, Earl-street, Westminster—Locomotive land battery.
749. F. Joyce, Upper Thames-street—Percussion caps.
751. S. Greenwood, Sunderland—Rivets, bolts, nuts, &c.

Dated 4th April, 1855.

753. J. Crowley, Sheffield—Malleable cast-iron.
755. L. A. M. Mouchel, Paris—Joining pipes, tubes, and ducts. (A communication.)

Dated 5th April, 1855.

757. W. Goostry, G. Hulme, and C. Hough, Chedderton—Paper.
759. J. Chesterman, Sheffield—Knives.
761. C. Goodyear, Paris—Self-inflating pontoons and life-preservers.
763. J. E. Frost, 135, Goswell-street—Ball cocks.

765. H. M. Holmes, Derby—Tyres for wheels.
767. A. H. A. Durant, Tong Castle, Salop—Axle and axle-box.

Dated 7th April, 1855.

769. W. B. Hays, 47, Cambridge-street, Pimlico—Breakwater.
771. H. Gerner, Moorgate-street—Polygraphic writing and drawing apparatus.
773. J. Hall, Liverpool—Grinding corn.
775. R, Husband and G. Mallinson, Manchester—Hat plush.
777. G. Walker, Belfast—Power looms.

Dated 9th April, 1855.

779. W. Tuer, W. Hodgson, R. Hall, and S. Hall, Bury—Looms.
781. D. Cope, Birmingham—Metallic spoons, forks, and ladles.
783. A. E. L. Bellford, Essex-street, Strand—Pumps. (A communication.)

Dated 10th April, 1855.

785. S. Fielding, jun., Rochdale—Lubricating pistons.
787. A. Chaplin, Glasgow—Steam boilers and combustion of fuel.
789. J. H. Johnson, 47, Lincoln's-inn-fields—Cotton machinery. (A communication.)
791. Lord C. Beauclerk, Riding, Northumberland—Tilling and subsoil ploughs.

Dated 11th April, 1855.

793. Capt. J. Addison, H.E.I.C.S., 23, Basinghall-street, and D. Sinclair, 122, Oxford-street—Scabbards and holsters.
795. L. and A. Oudry, Paris—Preserving wood, metal, &c.
797. J. Fletcher, Facit, Rochdale—Spinning machinery.
799. J. V. M. Dopter, Paris—Printing fabrics.
801. S. Holt, Stockport—Weaving plush.
803. P. A. Devy, 10, Old Jewry Chambers—Coke ovens. (A communication.
805. J. L. Norton, Holland-street, Blackfriars—Separating animal fibres from vegetable matters, and drying same.

Dated 12th April, 1855.

809. A. T. Richardson and G. Mallinson, Manchester—Piled fabrics.
811. J. Vernon, West Bromwich—Slide valves.
813. A. Cuninghame, Glasgow—Sulphuric acid and sulphates of iron and alumina.

Dated 13th April, 1855.

815. J. B. Bagary and C. Perron, Paris—Knitting machinery.
819. S. Wimpenny, Holmfirth, and J. Wimpenny, Rawtenstall—Spinning machinery.
821. R. A. Brooman, 166, Fleet-street—Treatment of fatty and resinous matters. (A communication.)
823. G. Turner, Northfleet—Tents and marquees.

Dated 18th April, 1855.

850. F. L. Han Dauchell, 4. Arthur-terrace, Caledonian-road—Regulating fluids and indicating pressure.
852. J. Fordred, Hampstead—Reflecting surfaces.
854. R. Bridge, Chadderton—Power looms.
856. B. Cook, Birmingham—Horse shoes.
858. J. Lawson and S. Dear, Leeds—Combing machinery.

Dated 19th April, 1855.

862. D. Pallier and E. Taylor, Broad-street, Lambeth—Soap.
864. E. and W. Howes, Birmingham—Carriage lamps.
866. J. Hindle, Accrington—Printing woven fabrics.
868. A. V. Newton, 66, Chancery-lane—Machinery for crushing and grinding mineral substances. (A communication.)
870. W. Jones, Rhodes, near Middleton—Printing fabrics.
872. F. Jacot, Paris—Starch.
874. J. Atherton, W. Boyes, and W. Lancaster, Preston—Temples for textile fabrics.
876. J. H. Johnson, 47, Lincoln's inn-fields—Railway breaks. (A communication.)

Dated 20th April, 1855.

878. L. Sardieu, Paris—Letters and figures for signs, &c.
880. H. Macé, Paris—Transferring colours or metals in design on and from paper and stone on to surfaces. (A communication.)
882. J. A. Manning, Inner Temple—Agitation of fluids and solid matters contained therein.
884. S. C. Lister, Bradford—Treating rheea plant.
886. R. Bright, Broad-street—Lamps and lamp-wicks.
888. A. V. Newton, 66, Chancery-lane—Bolt machinery. (A communication.)

Dated 21st April, 1855.

890. E. Pettitt, Manchester—Spinning machinery.
892. W. Hadfield, Manchester—Looms.
894. J. Barnett, 134, Minories—Smiths' hearths. (A communication.)
896. J. H. Johnson, 47, Lincoln's-inn-fields—Prevention of smoke. (A communication.)
898. W. Winter, Nottingham—Warp-looped fabrics.
900. W. C. T. Schæffer, Bradford—Treatment of waste wash-waters of mills.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

920. W. Symington, Little Bowden, Northampton—Preparing peas and pearl and Scotch barley for culinary purposes.—25th April, 1855.
954. M. Lyons, Suffolk-street, Birmingham—Enamel for coating metals and bricks.—27th April, 1855.

WEEKLY LIST OF PATENTS SEALED.

Sealed May 4th, 1855.

2202. Louisa Monzani, Greyhound-place, Old Kent-road—Improvements in bedsteads, and packing-cases or boxes to contain the same and other articles.
2203. Louisa Monzani, Greyhound-place, Old Kent-road—Improvement in brushes and brooms.
2337. George Lee Baxter, Sneinton Hermitage—Improvements in reaping machines.
2373. Paul Pretsch, Sydenham—Improvements in producing copper and other plates for printing.
2413. Pierre Joseph Meeus, Paris—Improved wind instrument.
2418. Richard Archibald Brooman, 166, Fleet-street—Improvements in the manufacture of thread from gutta percha and similar gums, in gilding, silvering, and ornamenting the same before or after being manufactured into fabrics, and in machinery and apparatus employed therein.
2441. Charles Asprey, New Bond-street—Improvements in handles particularly applicable to dressing cases, despatch boxes, writing cases, and other similar articles.
2455. Nicholas Callan, Maynooth College—Improvements in exciting agents used in galvanic batteries and in the construction of galvanic batteries.
2571. James Edward McConnell, Wolverton—Improvements in steam engines.
273. Thomas Barnabas Daft, Isle of Man—Improvements in the manufacture of beds or surfaces to recline or lie on.

Sealed May 8th, 1855.

2363. William Stead, William Spence, and Samuel Wood, Bradford—Improvements in machinery for preparing and combing wool and other fibrous materials.
2379. John Berry, Richard Berry, and Thomas Berry, jun., Rochdale, and Thomas Royds, Salford—Improvements in machinery for spinning, commonly known as mules.
2392. Henry Witthoff, Manchester—Improvements in the construction of boats, ships, or navigable vessels, and in the means of obviating or diminishing the dangers attending accidents to the same.
2402. Joseph Armstrong, Normanton Station, Wakefield—Improvements in chairs and crossings for the permanent way of railways.
2466. John Henry Johnson, 47, Lincoln's-inn-fields—Improvements in the preventing or removal of incrustation in steam boilers. (A communication.)
2497. Peter Armand le Comte de Fontaine Moreau, 4 South-street, Finsbury—Improvements in the construction of inkstands.
2538. James Biden, Gosport—The prevention of smoke from furnaces.
2564. Albinus Martin, Westminster—Improvements in the production of indigo dye colours in dyeing and printing textile fabrics and fibrous materials.
2676. James Langridge and Richard Langridge, Bristol—Improvements in stays or corsets.
2741. John Gray, Strand-street, Liverpool—Improvements in adjusting compasses on board ships or vessels.
320. Auguste Edouard Loradoux Bellford, 32, Essex-street, Strand—Certain materials to be used for cementing and painting, and also applicable to printing and dressing or finishing fabrics. (A communication.)
455. Andrew Small, Glasgow—Improvements in marine compasses, and in apparatus applicable thereto.
484. William Johnson, 47, Lincoln's-inn-fields—Improvements in coating iron and steel wire with other metals or alloys. (A communication.)
514. Thomas Walker, Birmingham—Improvements in rotary engines to be worked by steam or other fluid.
515. Antoine François Jean Claudet, Regent-street—Improvements in stereoscopes.
550. James Hulls, Plaistow, and John Lowe, Lambeth-road—Improvements in coating iron and other metals with lead.
562. Alfred Vincent Newton, 66, Chancery-lane — An improved construction of engine to be actuated by the expansive force of explosive mixtures.
577. Charles Goodyear, jun., 42, Avenue Gabriel, Champs Elysées, Paris—Improvements in the plates of artificial teeth.

WEEKLY LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
3712	May 4.	Scutari Tea Pot	Alexis Soyer	Scutari.
3713	,, 7.	Improved Portable Coffee Mill	Wm. S. Adams and Son	57, Haymarket.
3714	,, 9.	Improved Shirt Collar with Elastic Button Holes	Charles Rowland	Higher Tranmere, Chester.
3715	,, 9.	William Langdon's Saddle	William Langdon	9, Duke-street, Manchester-square, London.